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Food and dieteti..

Foods and Dietetics

(THEORETICAL AND PRACTICAL)

PART 1.

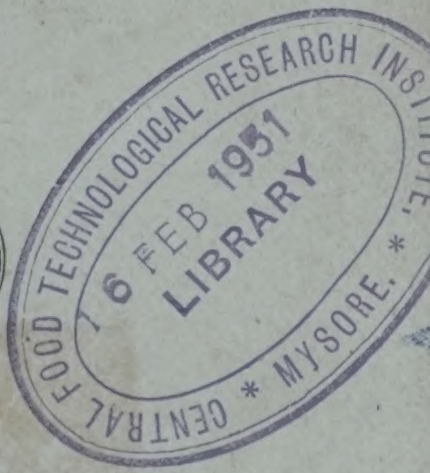
INTERMEDIATE DOMESTIC SCIENCE

By

W. MUNN RANKIN,
M.Sc. (Leeds), B.Sc., Hons. (London)
Formerly Principal, Municipal College, Burnley.

and

E. M. HILDRETH,
M.Sc. (Leeds)
Lecturer in Chemistry, Municipal College, Burnley, and Headmaster, Park Modern School, Colne.



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PREFACE

F recent years there has been little short of a revolution in the attitude of the ordinary citizen he problems of food and nutrition. In a new sense is becoming food-conscious—as much concerned h the quality in many respects of his food, as with its ntity; vitamins and mineral traces being as real to as the gross substance of his meals. His social science is also disturbed that so large a proportion of nation should lack food sufficient in kind and ntity to maintain a healthy physical life. There is d, however, for the interest and intelligence of the eral public towards matters of diet to be instructed guided, if the discoveries of research and the views of itians are to be properly appreciated and applied. s can best be done by means of formal courses of ruction to the emerging generation while yet at ool or college. This book is an attempt both to blish what is shortly termed food-science as a suitable ool subject in the intermediate and further years of ly, and to provide the general public with the materials an appreciation of the main problems of nutrition, well as with information of the sources and processing he commoner food materials.

heir long experience of the teaching of the scientific s of home economics to pupils of a wide range in age and aims has convinced the authors that it is ible to organize courses in this subject, to follow rally upon courses in elementary general science. t modern senior and central schools now possess er facilities of staff and laboratory accommodation, as have long been available in secondary schools for rimental instruction in physical science and biology. e facilities may be readily made available for instruc- in food-science, regarded as a development and nsion in the field of everyday life of the elements of ce that have been learnt earlier, and which most often ck of application are quickly forgotten. In technical tutions there are exceptional opportunities for making estic science as thorough a training of the young

housewife or cookery teacher as mechanical engineeri
for apprentice fitters. According to this view the pre
volume has therefore been developed upon a broad
of elementary chemistry and physiology, and with
especial emphasis on experimental exercises on
materials in great variety.

Most of the experiments may be performed with q
simple apparatus and an elementary technique,
therefore should offer no particular difficulty to the o
pupils in central and secondary schools, or the a
part-time students in technical institutions. In addit
there are a number of more difficult exercises which
properly be undertaken by full-time senior student
training colleges, who have already had a fair trai
in laboratory manipulation.

In its plan, the present volume falls into two
parts. The first division treats with the underl
principles of dietetics and deals categorically with
primary food substances, with stress upon their en
relations and chemical constitutions. The second divi
is occupied with rather detailed accounts of the comm
food materials, especial emphasis being laid upon
industrial aspects of their preparation for the consume

In the compilation of the volume the consider
mass of published and general information bearing u
food problems in their wider aspects has been freely u
with a view to making the volume, within certain li
reasonably comprehensive. These limits are those se
the types of reader and student for whom the volun
primarily intended—the intermediate and general, ra
than the advanced and specialist.

We are much indebted for illustrations to var
bodies : to the U.S. Bureau of Home Economics, Wash
ton, D.C., for the use of photographs illustrating relat
between growth and health and diet ; figures 1-4,
12-26 ; to the Cambridge University Press for the us
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SECTION A.—FOOD AND NUTRITION.

CHAPTER I.

GENERAL CONSIDERATIONS.

eat to live, and this is true of all other living isms. Physical life is both an unceasing activity ident upon energy, and a continual process of h, development and replacement of tissue, requiring ble building materials. Both energy and substance rovided from without as food.

e activity of the body takes many forms. It is evident in the movements of the limbs and of the of the chest and abdomen in the act of respiration, n the pulsation of the heart and arteries ; it is much vident in the usually quiet movements of the walls e alimentary tract. Activity is imperceptible yet more considerable in the many chemical changes on at all times in the myriad cells composing the n. Activity is the expression of the liberation or ference of energy, whenever work is done, resistance ome and masses moved, and when substances go chemical change. In the end all the energy erred or liberated appears as heat, for this is the t term or form of energy.

activity of any sort to be maintained by an organ- as also by any industrial prime mover, such as a engine, petrol motor or electrical motor, energy be first supplied it from outside and be liberated uired ; in the case of the heat engine or the body e combustion of fuel by oxygen taken in from the phere. Fuels as generally understood, such as oil, petrol and gas, are all substances which, when yield relative to their mass much energy or, as it st conveniently measured, heat. Foods serve as r the body and are all composed of substances of heat or calorific value. Fats when burnt yield

about 9 calories per gram, and an ordinary carbohyd
such as starch, 4 calories per gram. One gram
good steam coal yields 7·7 calories.

The carbohydrates and fats of fuel-foods are all prod
of the organised life of green plants; for plants conta
chlorophyll alone among the higher organisms have
power of converting substances with little or no intr
energy, such as carbon dioxide and water, into ca
hydrates of high energy content. This change is bro
about by the process of photosynthesis, which con
essentially in the taking up from the sunlight of rad
energy of particular wave-lengths. This conversio
represented shortly by the equation :—

$$6CO_2 + 6H_2O + \text{Energy} = C_6H_{12}O_6 + 6O_2$$

Carbon dioxide water glucose oxyge

The synthesis of one gram of glucose requires
calories of energy.

Fats are derived within plant and animal tissues
carbohydrates by the further process of loss of oxyge
reduction, and the taking up of more energy. Pro
are built up within plants from carbohydrates by
incorporation of the element nitrogen and in the ca
the higher proteins also of phosphorus and sulphur.
energy displayed by animals is derived from pla
either immediately eaten as herbage, seeds, fruits an
on, or in the case of carnivores, indirectly from
animals that have eaten such vegetable materials.
flesh is grass," and life as an activity is sunlight.
energy finally liberated by the various activitie
animals is but a restoration to the universe in the
of heat of the energy that has been stored for a perio
the tissues of the plants and animals consumed.

Food is also necessary to life as providing a sufficie
in kind and in quantity of various building materials
of which the body constructs new tissues, as in growth
development, and repairs the waste of tissues whi
continually going on, both at rest and in moven
The living stuff of all organisms, protoplasm, is comp
of proteins that are highly complex linkages and netw

nparatively simple units, some twenty in kind, the
-acids. The animal body can only form new tissue
onstitute old tissue from food that contains suitable
ns or, more strictly, particular amino-acids. Food
ns have all formed part of the living substance of
plants and animals, and before they can be used in
stem, are broken down by the process of digestion
heir component amino-acids. Although, like carbo-
tes and fats, proteins have a high potential energy,
they yield when oxidised in the tissues, their
r and economical use is not as fuels but as construc-
naterials.

bohydrates and fats as fuels and proteins as building
ials do not however completely satisfy the basic
rements of the body for its maintenance. To these
be added other primary substances: (i) water in large
ities, and at least two other classes of substances
y in very small amounts; (ii) the minerals, consisting
roup of particular elements; and (iii) the vitamins,
dozen of which have been distinguished. Minerals
itamins play very necessary, if not even absolutely
ial, roles in the maintenance of bodily health and
itself. They would appear to act as regulators of
n or "catalysts," for without them and similar
ts produced by the organism itself—the hormones—
hemical reactions in the cells cannot be started or
l through satisfactorily. They have been rather
y compared with the lubricants that make easy
g in machines, but their function is certainly far
omplicated. The significance of both minerals and
ns in a properly balanced dietary and in the normal
g of the metabolic processes of the body has only
ppreciated of recent years. It is now known that
bsence or shortage is the cause of a particular group
ases—the deficiency diseases—such as pellagra,
and scurvy.

he various articles of food eaten in the course of a
week when studied with respect to their chemical
are found to fall into a small number of distinct
f chemical substances. These are termed "proxi-

mate food substances" or "nutrients," and ar
follows :—

1. *Carbohydrates :* e.g., sugars, starch, glycogen (an
   starch), pectins, cellulose.
2. *Fats :* e.g., animal and vegetable fats and
   consisting in the main of tri-glycerides of var
   fatty acids but also including fat allies,
   lecithin of egg yolk and milk.
3. *Proteins :* e.g., albumin (egg, blood, meat), ca
   (milk, cheese), myosin (muscle), gluten (whe
   legumin (pulses).
4. *Minerals :* e.g., salts of sodium, calcium, magnesi
   iron, chlorine, iodine.
5. *Vitamins :* e.g., A, B complex, C, D, E, etc.
6. *Water.*

Alternatively these nutrients may be grouped
three other categories :—

A. *Energy or Fuel Foods.*
   Carbohydrates.
   Fats.
   (Proteins).

B. *Building and Repair Foods.*
   Proteins.
   (Carbohydrates).
   (Fat and Fat-allies).
   (Minerals).
   Water.

C. *Regulative or Protective Foods.*
   Minerals.
   Vitamins.

CHAPTER II.

FOOD AS SUPPLYING ENERGY.

gy irements. In the early stages of the study of nutrition emphasis was laid almost entirely on the energy or fuel irements of the body, and the energy or fuel value of s. This was natural, for the ordinary observation ving things is immediately concerned with their ements and other plain evidences of the output of gy in respiration and circulation. Energy is required nany internal purposes, and indeed when the body is est to a much greater extent than for the evident ements. Chemical changes are continually going n every one of the millions of cells in the body as are occupied in their routine operations, such as the ation, reduction and disintegration, and most ely in the cells of the various glands secreting mes and hormones or excreting waste products, as water, urea and uric acid. Every cell so occupied e scene of the transfer or liberation of energy. Food ituents after assimilation into the body are selected absorbed by the cells from the blood and lymph ing them; some are incorporated within the living ance of the cells as such or after molecular change, others are broken down into simpler products yielding gy as a by-product.

nong the chemical operations proceeding in the body may be briefly mentioned. The secretion by the ic (oxyntic) glands in the stomach of hydrochloric involves the conversion of sodium chloride trans- l from the blood plasma into 0·5 per cent. solution and calls for the supply of 9,000 calories for every grams of acid secreted. The hydrolysis of poly- arides (e.g., starch) and disaccharides (e.g., cane

sugar and milk sugar) to a simple sugar like gluco
the process of digestion is accompanied by the libera
of some energy, while the reverse process of condensa
of the glucose, derived from the blood stream by the
and muscles, into glycogen or animal starch take
energy. The excretion of water, salts, urea and sir
products from the blood by the kidneys, and of w
vapour and liquid as perspiration by the sweat glan
the skin also requires energy.

Carbohydrates and fats when assimilated in the tis
are readily oxidised in the living cells to carbon dio
and water, yielding energy, part to do useful chem
and mechanical work of various kinds which in the
will all produce heat, and in part immediately as h
and as such not convertible into work. In warm-bloo
animals the heat, however liberated, is of use in maint
ing the temperature of the body at a pretty cons
level (in the case of man at 37° C. or 98·4° F.), so ma
good the inevitable loss of heat by radiation and con
tion to the surroundings. When the body as a who
completely at rest the purely vegetative activities o
various organs and tissues still continue ; such as circ
tion, respiration, digestion, metabolism and radiat
and under these circumstances a basal value of h
production is established. When the body is engage
doing external work further demands are made upon
sources of energy, and still more heat is liberated wi
the system. The temperature of the body tends to
but usually adjustment is very quickly made by
increase in the amount of perspiration through the sw
glands, for in the conversion into vapour of the liq
water supplied from the blood to the sweat gla
considerable amounts of latent heat of evaporation
absorbed from the skin and tissues immediately beneat

During muscular activity, as in hard work
violent athletic exercises, the output of the body hea
increased considerably above the normal values of
or light work, over and above its equivalent of the ene
expended in this external work. For this increa

tput of heat and energy to be maintained without any
s in the solid substance of the body an extra amount
food, chiefly of the heat or energy-giving carbohydrates
d fats, must be assimilated.

When short periods are considered and the usual
sue stores are established, carbohydrates and fats
not accumulate in the body to any extent, and indeed
all practical purposes may be regarded as being
ickly and completely converted into energy and their
terial waste products, carbon dioxide and water.
oteins would appear to be stored to an even less extent
an carbohydrates and fats; any excess surplus to the
quirements of tissue-making is converted into carbo-
drates.

ergy Balance-Sheet of the Body.

Energy intake.	B. *Energy output.*
1. Potential energy of assimilated food; as liberated during intracellular respiration.	1. Heat loss from the body to outside. (*a*) By radiation from the surface. (*b*) By perspiration. (*c*) In expired breath. (*d*) In excretion of urea and fæces as direct heat and as potential heat.
2. (Heat energy of food eaten hotter than the body.)	2. External work done by the body by muscular action.

E Body as a Heat Engine.

As a means of converting the potential energy of food
o useful mechanical work the body behaves as a heat
gine, and just as tests of the efficiency of a steam
gine or petrol engine are carried through as a matter
routine in heat laboratories so the human body may
tested in a physiological laboratory.

Tests of the thermal efficiency of an ordinary heat engine are made roughly in the following fashion. A measured quantity of coal, petrol or coal gas of known calorific value is burnt in a boiler or exploded in a cylinder. Heat is liberated, raising the temperature and pressure of the working materials—that is the steam or gaseous products of combustion—and by the mechanism of the engine energy may be transmitted to a flywheel, where it is consumed in overcoming the resistance of a rope brake fitted with spring balances for measuring the differences of pull between one side and the other. Calculations are then made from the data of the experiments; first of the amount of heat measured in appropriate units liberated in the combustion of the fuel, secondly the amount of work done against the brake in terms of energy units, which are converted by the use of an appropriate Joule's equivalent into heat units, and finally of the thermal efficiency of the engine expressed as a ratio of these two; that is, of the heat units converted into useful work to the total heat units liberated in the combustion of the fuel. By such an experiment carried through with many precautions the thermal efficiency of a small steam engine is generally about 5 per cent., that of a large locomotive engine of the latest type 10 per cent., and of a high temperature Diesel oil engine 30 per cent.

In the case of the human body, the test takes the form of observing the amount of work done and its equivalent in heat units in a given time by a subject who is set to lift weights continually to observed vertical distances, or to pedal a fixed bicycle against a known resistance, and the amount of extra food calories consumed during the period of the experiment. Experiments on athletes and others have shown that in man the thermal efficiency of the process of conversion of the potential energy of food into mechanical energy is about 25 per cent. This means that one quarter only of the energy liberated from food during its complete combustion in the body can be converted into useful work, the remainder being immediately liberated as heat.

One pound or 453·6 grams of sugar when burnt in a bomb-calorimeter liberates 1,860 calories of heat, equivalent to $1,860 \times 427$ metre-kilograms of energy or work (427 being the appropriate Joule's equivalent for the conversion of calories into metre-kilograms). At the most, therefore, the consumption in the body of one pound of sugar will effect only a quarter of this amount of work, namely 465×427 metre-kilograms, the remaining three-quarters of energy being liberated within the body as heat, and if the temperature of the body is to remain constant must be quickly dissipated through the skin or breath.

The body is a scene of many more operations than the erformance of external work in occupation or exercise, nd account must be taken of the food energy required or what might be termed the ordinary overhead charges f the body. Other types of experiments are employed o arrive at a measure of the general energy requirements nder various circumstances of rest and activity, and cidentally of the quantities of fuel-foods needed to aintain the body in good working order. For the urposes of these determinations the body at rest—that doing no external work of any sort—may be regarded s a combustion stove receiving food as fuel, taking in xygen from the atmosphere by way of the lungs, to burn he assimilated food substances in the tissues and liberating here three distinct and independently measurable uantities—heat, carbon dioxide and water.

Heat balance is established by measuring (i) the input f energy in the form of food or of food-stores consumed ithin the body—the heat equivalent of which can be etermined by separate experiments, and (ii) the output energy as heat alone during rest, and as heat and xternal work during occupation or exercise.

alorific Value of Food.

The energy or calorific value of a food may be obtained rectly by burning a known quantity in a bomb-calori-eter in an excess of oxygen and observing the increase temperature of the known quantity of water surround-g the combustion chamber into which all the liberated at passes. The amount of heat produced is given by e product of the mass of water and its temperature rise British Thermal Units (pound degree Fahrenheit) or as alories (kilogram degree centigrade).

In practice a more convenient method of obtaining the lorific value of food is followed. The heat-giving nstituents of all foods are carbohydrates, fats and oteins. The average calorific values of these three imary constituents have been obtained by the ordinary

bomb-calorimeter combustion of pure substances. For an average food carbohydrate such as starch, the value is 4·1 calories per gram, for a fat such as palmitin, 9·3 calories per gram, and for an average flesh protein as oxidised in the body 4·1 calories per gram. (One gram of an average flesh protein yields on complete combustion in a calorimeter 5·6 calories, but in the body oxidation is not so complete, for the nitrogen of the protein is excreted not as poisonous oxides of nitrogen but as more or less innocuous urea, uric acid and similar substances with a residual energy of between 2·5 and 2·7 calories per gram : the heat yield in the body is taken as 4·1 calories per gram).

A very large number of different food substances have now been analysed in terms of their constituent carbohydrates, fats and proteins and their calorific values are usually calculated in terms of these three factors. They are readily available in publications such as "Analyses and Energy Values of Foods," by R. H. A. Plimmer (H.M.S.O., 1921, 6*s*.)

The tables enable one to calculate readily the calorific values of any particular food, meal or dietary over a period of days or weeks ; thus

Example A.

1 lb. of Pork contains 67·6 grams Protein, 111·1 grams Fat and no Carbohydrate.

The protein will yield 67·6 × 4·1 calories	= 277·16 Calories.
The fat will yield 111·1 × 9·3 calories	= 1,033·23 „
	1,310·39

The Calorific value of Pork is 1,310·39 Calories per lb.

Example B.

Beef Collops :—

1 lb. Mince Meat, raw.	1 oz. Flour ; ¼ pint Water.
4 oz. Onion.	Pepper and Salt.
1 oz. Dripping.	2 Slices Toasted Bread.

Food.	Quantity	Proteins. in grams	Fat in grams.	Carbo-hydrates in grams.	Calories.
Meat	1 lb.	85·3	83·5	—	1,126
Onions	4 oz.	2·0	—	10·5	50
Dripping	1 oz.	—	28·4	—	264
Flour	1 oz.	1·8	0·45	21·4	104
Toasted Bread ...	2 oz.	4·1	0·11	27·0	130
	1 lb. 8 oz.	93·2	112·46	58·9	1,674

Distribution of energy among the nutritive principles.

	Quantity in grams.	Factor.	Calories.
Protein	93·2	4·1	382·12
Fat	112·46	9·3	1,045·88
Carbohydrate ...	58·9	4·1	241·49
			1,669·49

Example C.

Family dietary record.

To make such a record the separate ingredients of the meals of a family over a particular period, say, a week, are all weighed and their food values determined with the aid of tables. The example taken is from the British Medical Association's Report on Nutrition (page 36) :—

Diet No. 14.

Man, wife and three children (1-2 years, 2-3 years and 3-6 years). Equivalent to 3·03 "men." (See page 30).

Item.	Quantity	Protein grams.	Fat grams.	Carbo-hydrate grams.	Calories.
Beef	1½ lb.	127·9	125·2	—	1,689
Mutton	½ lb.	25·2	84·6	—	890
Minced meat ...	2 lb.	170·6	167·0	—	2,252
Bacon	1 lb.	46·7	245·8	—	2,478
Corned Beef ...	½ lb.	59·6	42·4	—	639
Cheese	2 lb.	233·2	317·6	28·2	4,022
Milk	24½ pts.	458·1	499·8	666·4	9,261
Kipper	1 lb.	64·0	50·4	—	730
Butter	½ lb.	0·4	188·2	—	1,751
Lard (dripping) ...	½ lb.	—	226·8	—	2,109
Flour or	17½ lb.	801·5	127·8	5,993·8	29,050
Bread	28 lb.	(915·6)	(25·2)	(6,109·6)	(29,036)
Sugar	5¼ lb.	—	—	2,381·4	9,765
Jam	1 lb.	1·4	—	314·8	1,296
Potatoes	7 lb.	60·2	0·7	574·7	2,611
Yeast	¼ lb.	—	—	—	—
Tea	½ lb.	—	—	—	—
Oatmeal (med.) ...	½ lb.	27·0	19·5	158·7	943
Rice	½ lb.	13·4	0·9	182·1	810
Treacle	½ lb.	3·6	—	135·8	572
Barley	½ lb.	15·8	1·8	181·2	825
Fresh fruit and green vegetables	—	—	—	—	500
Total weekly quantities ...	—	2,108·6	2,098·5	10,617·1	72,193
Daily quantities per "man" ...	—	99·4	98·9	509·6	3,404

Energy Output of the Body. The energy liberated within the body as a result of the oxidation of substances of high energy content can be determined in either of two ways: (i) by direct calorimetry; or (ii) by indirect calorimetry; the former method using the Respiration Calorimeter and the latter depending upon the measurement of either the amount of oxygen absorbed or the amount of carbon dioxide given off in respiration.

DIRECT CALORIMETRY. This, the most direct method of measuring the total amount of heat given up in a given time by a person serving as the test subject, is for him to be enclosed in a suitably large chamber equipped as a calorimeter. The walls of the chamber are lagged with non-conducting materials (dry air, slag-wool or sea-grass) so that no heat can pass through in either direction. The subject is free to breathe in air, or preferably oxygen, which is kept passing into the chamber by means of a fan, and the expired air before passing again to the atmosphere, or alternatively back again into the chamber, is first cooled to its original temperature, and then its contained moisture is absorbed by oil of vitriol soaked in pumice stone, and its carbon dioxide by potash or soda lime. The heat continually given out by the body from its surface to the atmosphere of the enclosure is withdrawn by heat absorbers placed conveniently in the inner walls of the chamber, and its amount is readily calculated from the quantity of water passing through the absorbers in the period of the experiment and the difference of temperature at its entrance and exit—the current being so adjusted that this difference is kept constant under the particular conditions of the experiment. These conditions may be varied, as between the subject being at rest—waking or sleeping—or being occupied in various grades of activity—mental or muscular. Usually the person subjected to calorimetry has fasted for a period of 12 to 16 hours previously and drunk no water for the past 4 hours, so that the alimentary tract may be regarded as being no longer engaged in the processes of digestion or assimilation. When the conditions are those of rest, he must remain awake and, more than lying perfectly still, must not worry or occupy his mind in any sort of activity.

If external work is done its equivalent in heat units is calculated and these are added to those liberated within the calorimeter chamber.

INDIRECT CALORIMETRY More convenient methods depend upon the measurement of either the volume of oxygen absorbed from the atmosphere

during respiration or the volume of carbon dioxide excreted. The oxygen absorbed is used almost immediately in intracellular combustion and none of it is stored, so that it is a ready and accurate measure of the amount of metabolic activity. The ratio of carbon dioxide gas discharged from the body to the amount of oxygen taken in during a given period is known as the "Respiratory Quotient" (R.Q.).

In outline, the method of indirect calorimetry consist in collecting the air expired by the subject during a given time into an air-tight bag of 50 litres capacity and from the analysis of the air so expired in terms of its oxygen, or of its carbon dioxide, compared with that of the air as breathed in, to calculate the total amount of oxygen absorbed by the lungs or alternatively that of the carbon dioxide excreted in exchange.

Analysis of Air—Inspired and Expired

	Inspired Air Volume per cent	Expired Air (Dried) Volume per cent.
Oxygen	20·93	16·60
Nitrogen	79·03	79·40
Carbon dioxide ...	0·04	4·0

Nitrogen is not absorbed in the body, so that the amount of oxygen inspired corresponding to 79·40 ccs. of nitrogen in the expired air will be

$$\frac{20{\cdot}93 \times 79{\cdot}40 \text{ccs.}}{79{\cdot}03} = 21{\cdot}03 \text{ ccs. in } 100{\cdot}48 \text{ ccs. of inspired air.}$$

The amount of oxygen consumed will be (21·03—16·60) ccs. =4·43 ccs. out of every 100·48 ccs. inspired air.

The Respiratory Quotient in this case will be

$$\frac{4{\cdot}0}{4{\cdot}43} \frac{CO_2}{O_2} = 0{\cdot}9$$

The values of the Respiratory Quotient and of the heat equivalent of the absorbed oxygen depend upon the character of the food-reserve consumed within the body.

n the combustion of a pure carbohydrate the Respiratory Quotient is unity, and one litre of oxygen corresponds o th liberation of about 5 calories. Thus, if the olume of oxygen absorbed in 5 minutes during the ombustion of a reserve carbohydrate is 1·371 litres the mount of heat evolved during the period is reckoned as pproximately $5 \times 1{\cdot}371$ calories, or at the rate of 1,974 alories per day.

The Respiratory Ratio corresponding to the combustion f an average pure fat is 0·7, and of an average flesh-rotein 0·8. The heat equivalents of 1 litre of oxygen re 4·70 calories for a typical fat, and 3·91 calories for a rotein like milk albumin, when burnt in the body. nder resting conditions the combustion is one of mixed eserves and the Respiratory Quotient is about 0·82 and ne corresponding heat value of the absorbed oxygen is ·83 calories per litre.

Calculation of Respiratory Quotients and Heat Equivalents of oxygen absorbed and carbon dioxide evolved.

1. CARBOHYDRATES

Example—Glucose

$$C_6H_{12}O_6 + 6O_2 = 6CO_2 + 6H_2O$$

(*a*) 6 volumes of oxygen yield 6 volumes of carbon dioxide

$$\text{Respiratory Quotient} = \frac{6 \text{ volumes of } CO_2}{6 \text{ volumes of } O_2} = 1$$

(*b*) 1 " mol " or 180 grams of Glucose take up $6 \times 22{\cdot}42$ litres of oxygen.

100 grams of glucose absorb 74·7 litres of oxygen.

∴ 1 litre of oxygen is equivalent to 1·34 grams glucose.

(*c*) 1 gram glucose yields when burnt 3·75 calories

∴ 1 litre of oxygen is equivalent to $1{\cdot}34 \times 3{\cdot}75$ calories
= 5·02 calories.

2. FATS

Example—Palmitin

$$2\,(C_{15}H_{31}CO)_3.C_3H_5O_3 + 145\ O_2 = 102\ CO_2 + 98\ H_2O$$

(*a*) 145 volumes oxygen produce 102 volumes carbon dioxide

$$\therefore \text{Respiratory Quotient} = \frac{102\ CO_2}{145\ O_2} = 0{\cdot}7$$

(*b*) 2 "mols" or 1612 grams of palmitin take up $145 \times 22{\cdot}42$ litres of oxygen

$\therefore$ 100 grams of palmitin absorb 201 litres of oxygen.

(*c*) 1 gram of palmitin when burnt yields 9·45 calories

$\therefore$ 1 litre of oxygen is equivalent to $\frac{9{\cdot}45}{2{\cdot}01}$ calories

$= 4{\cdot}70$ calories

and 1 litre of carbon dioxide is equivalent to 6·7 calories.

3. PROTEIN

Example—Lactalbumin

$$2(C_{644}H_{1064}N_{160}S_8O_{214}) + 1381\ O_2 = 166\ CON_2H_4 + 1122\ CO_2 + 716\ H_2O + 16\ H_2SO_4$$

(*a*) 1381 volumes of oxygen yield 1122 volumes of carbon dioxide

$\therefore$ Respiratory Quotient is $\frac{1122\ CO_2}{1381\ O_2} = 0.81$

(*b*) 2 "mols," or 29,402 grams, of lactalbumin take up $1381 \times 22{\cdot}42$ litres of oxygen

$\therefore$ 100 grams of lactalbumin take up 105 litres of oxygen.

(*c*) 1 gram of lactalbumin when oxidised in the body yields 4·1 calories

$\therefore$ 1 litre of oxygen is equivalent to 3·91 calories and 1 litre of carbon dioxide is equivalent to 4·82 calories.

Respiratory Exchange in Man (after Benedict and Cathcart)

	Oxygen absorbed in ccs per minute	Carbon Dioxide discharged in ccs per minute	Respiratory Quotient	Calories per minute
Resting	242	218	0·90	1·2
Moderate Work	1,490	1,224	0·81	7·1
Severe Work ...	1,850	1,789	0·97	9·3

In this case it would appear that the reserve material burnt in the course of metabolism while at rest, and especially so while occupied in heavy work, is largely carbohydrate in character, and that during moderate work other materials,—fats and proteins—are burnt in relatively greater amounts.

nergy requirements f the body.

An estimate of the all-round energy requirements of an individual and of the amounts of food, o that he can maintain himself without any loss of weight nd fully competent in health to follow his particular ccupation, is arrived at by the summing up of the eparate and distinct requirements of the several states f his daily round—sleep, waking, rest, activity and eisure.

Basal Metabolic Rate.

Of primary importance is what is termed the Basal Metabolic Rate. This is the amount of heat given out, nd so of tissue-energy or food consumed, in a unit period uring absolute waking rest, that is when there is no xternal work of any sort being done, and even no onscious brain work. This value indicates the rate at hich tissue oxidation is taking place and energy being berated within the body as a whole, while it is on what ight be termed simple maintenance. In this state here are being carried on within the many cells of the ystem the intimate chemical processes of respiration, igestion, assimilation, circulation, secretion, excretion, nabolism or the building up of tissue, and catabolism or he breaking down of tissue. In all these processes nergy is a primary essential; it is derived primarily rom food and more immediately from it as digested and ssimilated, and is ultimately liberated to the outside as eat.

The basal metabolic rate varies with many factors; hief of which are the physical disposition, gross dimenions of the body, age and sex of the individual and the hysical conditions of the environment.

An individual with a low rate can carry on the essential r purely vegetative functions of his body with the onsumption of less than the average amount of energy r food. If he follows the usual diet he has more energy o spare for work, but if he is lethargic and generally

easy-going in disposition and does not exercise his body, he is liable to store fat and become obese. On the other hand an individual with a high rate of combustion consumes much more mental and physical energy and, storing little if any reserve substance in his tissues, is inclined to be spare of build. The highly strung neurasthenic, though he may have a good appetite, eating liberally of all kinds of food, remains thin as the result of what might be called a forced draught or excessive expenditure of energy needed to maintain all his bodily and mental functions, automatic as well as conscious.

Generally speaking, the rate is found to be constant for any individual adult from day to day, or even over longer periods; it varies slightly over periods of years, and is but little modified under the different conditions of the successive phases of life.

The rates would appear to be largely bound up with the behaviour of the endocrine glands, and more particularly the thyroid and adrenal glands, or rather with their specific secretions or hormones, thyroxine and adrenaline. The results of thyroid deficiency are very evident in the disorder myxœdema, when many of the bodily functions including the pulse, temperature and mental responses, as well as general oxidation, are markedly slowed down. The total absence of thyroid activity lowers the heat production to 60 per cent. of the normal amount, and with an enfeebled metabolism there is a tendency to accumulate fatty tissue generally. The contrary state of thyroid excess, as in exophthalmic goitre, is characterised by all the signs of excessive metabolism, such as rapid pulse, quick breathing, ever-present perspiration and lively nervous activity. While the effects of thyroxine, whether in excess or in deficiency, are chronic, those of adrenaline are temporary, being displayed only during transient emotional disturbances, such as anxiety, rage, fright and fear. The sub-normal functioning of the pituitary gland, another ductless gland,

accompanied by a lowering of the metabolic rate, and displayed by lethargy, obesity and retarded or deficient telligence.

The basal rate varies with the dimensions of the body. hen the matter was first considered the value was lated to the gross weight of the body, and the differences nored or evened out as between the various tissues—ands, muscles, nerve, cartilage, bone, etc.—with their ry different energy requirements. The basal metabolic te of a man of average height and say, 11 stones 0 Kgs.) in weight, was found to be between 1,700 and 000 calories daily, that is, 1 to 1·33 calories per kilogram eight per hour. Nowadays it is customary to relate e metabolism to the superficial area of the body, and express the heat output in terms of calories per square etre of body surface. The value for the body surface is rived from the weight and the height by means of an mpirical formula, usually that of Du Bois.

$$S = W^{0\cdot425} \times H^{0\cdot725} \times 71\cdot84.$$

Where S = Surface in square metres.

W = Weight in kilograms.

H = Height in centimetres.

and 71·84 is a constant.

The average adult man with a skin area of 1·75 square etres has a basal output of 40 calories per square metre r hour, which corresponds to 1,700 calories per day: e average adult woman with a surface of 1·5 square etres has the rather less output of 37 calories per square etre per hour. With young children and adolescents e figure is definitely higher, e.g., 60 calories at six years age, and 50 calories at puberty. These latter figures e undoubtedly related to the rapid increase in growth d development taking place in the young, and at dolescence to the profound changes in the glandular

tissues. During the later stages of life when growth and development have long ceased and glandular activity is much diminished the value progressively decreases.

Average Values for Basal Metabolic Rate in Man.

Age	Calories per sq. metre per day
New born	800
1-2 years	1,200
10-13 years	1,300-1,100
13-16 years	1,200-1,000
16-30 years	1,100- 900
30-80 years	1,000- 800

Sleep lowers the basal value from the normal figure of 40 calories by 10 to 16 per cent., and the digestion of food raises it by 10 to 20 or more, per cent.

Departures from the average state are observed in the case of illness. During fever, when the body temperature is appreciably raised, the basal value is also increased. The increased demand then made on the energy stored in the tissues is usually met by the combustion, first of fat to carbohydrate and then of this to water and carbon dioxide, and in the course of the fever increasingly by the combustion of the protein substance of the tissues themselves. It is usual in illness to cut down very considerably the amount of food consumed, so that as a result there is often a considerable wasting of tissues of all kinds. Malarial fever is marked by a succession of fevers and chills, each phase calling for an increase of fuel energy, and in the aggregate resulting in a very considerable increase on the basal rate.

Exposure to low atmospheric temperature and a reduction in the amount of protective clothing are each

companied by a loss of heat by radiation which stimulates ivering, a violent and spasmodic muscular activity. his results in the liberation of extra heat within the ripheral system, tending to balance the loss to the tside. The provision of suitable clothing and the nditioning of the air of inhabited rooms according to the mate and the seasons of the year, now becoming the neral rule among civilised men, even-out the wide riations in the metabolic rate which are inevitable under tural conditions of life.

ECIFIC NAMIC ACTION

Diets rich in fuel foods such as fats, and to a less extent carbohydrates, and especially when quickly burnt in the body, appreciably increase basic rate. When the diet is especially rich in the higher proteins neat, the rate is further increased on account of what is termed the ecific Dynamic Action. It is found that the actual amount of at liberated in the body under such circumstances is definitely ater—in the case of proteins up to 11 per cent—than the amount neat calculated from the quantities of the nutritive constituents of food ingested. The excess liberation of heat in the case of the teins is ascribed to the stimulative action not so much of the teins, as such, but of their amino-acids; some five of these, enylalanine, tyrosine, glycine, alanine, leucine, have been shown to of particular significance. Various sources of this extra amount neat have been suggested, such as the breakdown in the liver of the ino-acids themselves and their stimulation of cellactivity generally; the matter is not yet settled. Other food substances as fats in ess, and soluble carbohydrates as glucose, have also a similar ion, although much slighter.

IE BODY AT WORK.

So far we have been considering only what might be koned as the overhead charges of the body in the tter of energy; there yet remains to be considered its erating expenditure incurred when it is engaged in ternal muscular activities, whether of occupation, ercise or leisure.

A very large number of very careful determinations ve been made on the energy requirements of the body en engaged in different types of occupation, as of men

following various classes of sedentary occupations
performing tasks of widely different degrees of physi
labour. Direct measures of mechanical output
available from experiments performed on individuals w
have been subjected to such mechanical tests as pedalli
steadily for periods on a fixed bicycle, or ergomet
driving a small dynamo thereby producing electri
energy, which is transformed into heat when the current
passed through a resistance, as an electric lamp. T
external work is accompanied by the direct evoluti
within the system of heat some three times its amount, t
thermal efficiency of the body being reckoned at about
per cent.

Generally the determination of the total heat evolved
the system depends upon the methods of direct calo
metry (page 13), or of indirect calorimetry (page 1
A very large number of values of the calorie-requiremer
of men at rest or working under different conditions
now available, and have been used to arrive at what mig
be fairly considered standard values for different types
workmen.

Under normal conditions the average manual labour
during a period of eight hours does mechanical work
between 80,000 and 90,000 metre-kilograms, an amou
equivalent to 200 calories. Taking into account t
efficiency factor of 25 per cent, this work requires a to
intake by way of food of 800 calories, quite apart from th
needed to balance the outgoings of the basal metabolis
A man engaged in more heavy labour as stone-cutting,
in strenuous athletic exercise as running, sculling
mountaineering, uses very many muscles and perfor
even greater amounts of external work with hea
demands upon the food stores within the tissu
generally.

A schedule may be drawn up as below, which sets out t
allocation of the tissue- or food-energy to the separa
functions and activities of the body under the successi
phases of daily life of an average manual worker.

rgy Requirements of an Average Manual Worker per day of 24 hours.

(*After Cathcart.*)

	Calories per hour
a :—	
. Basal rate of waking rest, covering essential functions only	68
. Basal rate of sleeping rest : the former rate diminished by 10 per cent.	62
. Increment to cover average day labour of eight hours, equal to 800 calories	100
. Increment to cover general activities of an active leisure, say 75 per cent. of the basal rate	51
alysis :—	
Sleep of 8 hours :—	Calories
Basal metabolism of sleep—8 hours at 62 calories	496
Working period of 8 hours :—	
Basal metabolism of working—8 hours at 68 calories	544
Work increment—8 hours at 100 calories	800
Leisure period of 8 hours :—	
Basal metabolism of waking—8 hours at 68 calories	544
Leisure increment—8 hours at 51 calories	408
Total for the day ...	2,792

Such a man on a full day would have a heat output practically 2,800 calories: but taking into account week-end rest and the rule of 48 hours working week, t schedule would need to be somewhat modified as follows

	Calories
Sleep :—	
7 periods at 496 calories	3,472
Work :—	
48 hours per week. 6 periods at 1,344 calories	8,064
Leisure :—	
60 hours per week. 8 periods at 952 calories	7,616
Total for the week...	19,152
Average per day ...	2,736

The value of roughly 2,700 calories per day would ne to be met for the maintenance of this hypotheti worker in full working condition by an equal intake energy in the form of food. It would not however be su cient to calculate from the tables of food values t calorific values of such food as he has provided him home, for allowance must be made for waste, both bef and after cooking, and as leavings on the plate. If th are put at 10 per cent., the value of the daily average 2,700 calories would be raised to a little under 3,0 calories as being required for a man performing lig manual work.

The Report of the Committee on Nutrition appoint by the British Medical Association, which was issued 1935, went further, and held that it is doubtful wheth 3,000 calories in food as purchased are sufficient to mai tain the working capacity of an adult worker, if his wo entails any considerable amount of muscular exertio An amount of 3,400 calories in the food as purchase assuring 3,000 available calories, was given as a s figure for the daily requirements for a man of avera

ld. leading a healthy life with moderate muscular vities. This figure closely corresponds to the effective rmy Ration at Home." Hitherto, the great majority abourers and heavy manual workers in this country e not had such a reasonably liberal supply of food rgy daily, owing very largely to the lowness of their ges, and to a certain extent to the lack of knowledge, and ome cases also of marketing and cooking facilities, of average working housewife.

Daily Calorie Requirements and Outputs

nference of Ministry of Health and British Medical Association, 1934)

	Calories.
Rest	2,400
Light Work, e.g. sedentary work as of tailors, bookbinders and shoe-makers. Clerks	2,600-3,000
Moderate Work e.g., metalworkers, carpenters, painters, agricultural workers	3,000-3,400
Heavy Work, e.g., as labourers ...	3,400-4,000
Very Heavy Work, e.g., stonemasons	4,850
Woodcutters	5,500
Road-racers	9,000

rces of d Calories

The chief sources of tissue-energy are the carbohydrates and fats of food. Carbohydrates in the form of starch sugar are the cheapest supply and the most readily sted and assimilated; they constitute what is for the rest section of the community the staff of life. Even se who can afford any food they wish, in practice end largely upon foods rich in carbohydrates for the n supply of their energy. Fats have much higher rgy content than carbohydrates (9·3 calories per gram against 4.1 calories) and are generally eaten with bohydrates in some form or other in a balanced diet,

such as bread and butter. The total and relative quantit of fat that may be eaten largely depend upon the urg energy requirements of the body. A slight excess requirements tends to be stored, but a large excess is lia to set up ketosis or acidosis, owing to incomplete oxidat (see page 158), while a marked deficiency encoura rickets and tuberculosis. A man doing light work i temperate climate requires about 100 grams of fat da which provides between 20 and 30 per cent of his ener while a navvy or lumberman demands a much more libe allowance so that it may provide at least 40 per cent. of total energy output, of anything between 4,000 and 5,(calories. Inhabitants of cold climates, so that they m balance the great loss of heat to the outside, obtain ev larger proportions of their energy from fat foods : Eskimo eats anything up to 170 grams of blubber a d and on the average obtains about one half of his energy fr it, the remainder being met very largely by meat and proteins, carbohydrates of necessity being lacking. contrast the Bengali peasant eats but little fat and depe to an extent of 80 per cent of his energy upon the c bohydrates of cereals of which there is usually a rea and abundant supply.

While the typical fuel foods are carbohydrates and f and the primary use of proteins is to build up new tis and to replace the waste tissue, proteins also serve a subsidiary supply of energy. This is especially so wh proteins are eaten in excess, for they are then larg converted in the liver by the process of de-aminizati into carbohydrates, so becoming available as a dir source of energy, and ammonia derivatives. When remaining proteins that are assimilated into the tissues broken down in the course of metabolism further energy liberated.

The correct distribution of energy supply as between three primary food constituents has long been a matter experiment and controversy, but it is now generally accep that under ordinary conditions of life in temperate clima equal quantities of protein and fat should be eaten—e

grams daily—and that the carbohydrates in much
er quantities—500 grams daily—should be depended
n to provide the greater portion of the energy needed.
distribution suggested by the British Medical Associa-
Committee on Nutrition is as follows :—

l Calories required daily per man-unit (3,400 Calories. Gross)

Source	Quantity in Grams	Calories	Percentage of Total Calories
ein 1st Class	50	50 × 4·1 = 205	6) = 12
2nd Class	50	50 × 4·1 = 205	6)
... ...	100	100 × 9·3 = 930	27
ohydrate ...	500	500 × 4·1 = 2,050	61
	700	3,390	100

ALYSES OF NERAL DIETARIES

Individual and sectional deviations from what can be fairly regarded as a standard distribution of food ories appropriate to a particular community prove to be en very considerable. Even where there are available he markets and stores a very varied and ample supply foods the determining factor as between one allocation energy source and another is very largely a matter of nily income. The better-off members of a community h prefer and afford food of high energy value, which is n in flesh proteins and fat, rather than an abundance of bohydrates such as that upon which the poorer people e come to depend largely for their calorie intake, in the m of bread, porridge and potatoes. Any improvement the family circumstances quickly shows itself in an rease in the purchase of meat foods and in a fall in the sumption of cereals and roots. This general observa-n was subjected to a most critical analysis by Cathcart d Murray in their investigations of 1930 to 1933 in St. drews, Cardiff and Reading.

These two investigators surveyed the diets of a numb of families, rich and poor, in St Andrews, comprising in a 745 persons. The diet of each family was recorded for week, and the energy value and the distribution of calori between protein, fat and carbohydrate determined, well as the money spent on food. The average of all t figures arrived at showed a calorie consumption of 3.1 per man, per day, which was derived from 89 grams protein, 119 grams of fat and 411 grams of carbohydrat the distribution of calories being 11 per cent. from protei 35 per cent. from fats and 54 per cent. from carbohydrat When the families were grouped according to the tot weekly income, it was found that the energy intake per m was larger the higher the income, and that the increase energy was derived chiefly from fats and to a less exte from proteins. The Scotch tradition of economy in me was plainly strong. It was also clear that the ratio calories per pence spent increased as the family income fe A grouping of families according to income and occupati showed that the sedentary worker consumed more fo than the artisan. The adequacy of the family diet indicated by the state of nutrition of the children w satisfactory in every class except among the unemploye where the average intake of energy was dangercu below the standard.

Summary of St. Andrews Families data (1932)

Grade	Proteins in Grams	Fats in grams	Carbohyd-rates in grams	Calorie per da
Professional Classes	100	150	445	3,638
Shopkeepers	90	130	437	3,354
Skilled Workers...	87	122	429	3,239
Unskilled Workers	73	97	387	2,776
Unemployed ...	58	74	287	2,089

The same two investigators also published the results of ir surveys of the diets of 56 families in Cardiff compris- 370 persons, and of 56 in Reading comprising 378 sons, chosen on these occasions from among the same izontal section of the community. The man-value per ily in Cardiff was 4·55 and 4·35 in Reading. The rage calorie consumption per man per day in Cardiff s 3,174, and was obtained from 79 grams of protein, 114 ms of fat and 441 grams of carbohydrate. The responding figures for Reading were 2,906 calories ived from 75 grams of protein, 101 grams of fat and grams of carbohydrate. The distribution of energy ween the nutritive principles in each case was about 10 cent. from protein, 32·33 per cent. from fat, and 57 per t. from carbohydrate.

N VALUE WOMEN D CHILDREN

For the calculations of the proper allocation of calories and food quantities to members of a family, schedules of family co-efficients have been drawn by different researchers. That drawn up by Cathcart Murray is the one usually adopted in this country as eeing well with general practice and tradition. The ner of a family on the average needs more food than his e, and young children less than their mother: but a wing youth will require as much as his father, and his er over 14 as much as her mother. A young, rapidly wing child, weight for weight, requires a much greater ntity of food, and that of a more richly nutritious racter and therefore more expensive than either of his ents. An adult requires on the average 20 calories per per lb. of body weight, but a baby requires 50 calories day per lb. of body weight. At the other extreme, old person usually requires appreciably less food than a son in his or her prime. From the schedule of family fficients an adult man being taken as unity it is easy calculate the requirements of a family as a whole in l man-units or "man value," and also taking the rie amount of a man at 3,400 gross calories, as bought, calculate the full daily calorie requirements of any ticular family.

MAN VALUES AT DIFFERENT AGES (Cathcart and Murray)

Age and Class	Calorie Co-efficient Man value = 1	Cost	Calorie per day
Adult Male (Father) ...	1·00	1·00	3,400
Adult Female (Mother)	0·83	0·83	2,840
do. (Pregnant)	1·00	1·00	3,400
do. (Nursing) ...	1·25	1·25	4,250
Boy over 14 ...	1·00	1·00	3,400
Girl over 14	0·83	0·83	2,840
Child 1-2 years	0·30	0·47	1,020
„ 2-3 „	0·40	0·54	1,360
„ 3-6 „	0·50	0·59	1,700
„ 6-8 „	0·60	0·60	2,040
„ 8-10 „	0·70	0·71	2,380
„ 10-12 „	0·80	0·80	2,720
„ 12-14 „	0·90	0·90	3,060
Old Persons over 65 ...	0·75	0·75	2,550

CHAPTER III.

OD AS SUPPLYING STRUCTURAL MATERIALS.

Ve have been considering so far in special detail the ction of food as a source of energy for the system, but the dy is more than a heat stove or heat engine, it is a living anism that has to be built up in development and wth from a microscopical cell before birth through child- d and youth to maturity, and at all times to be intained in health and good working condition so as to form satisfactorily its many internal and external ctions. The basal substance of life, the cell protoplasm, sists of the highest type of protein, and from it are derived ious other proteins distinctive of the non-living substance the different tissues, such as muscle, nerve, blood, bone, nective tissue and so on. Protoplasm as a living sub- nce is characteristically undergoing continual changes chemical structure, some resulting in break-down rogenous products which are voided from the system, inly by the kidneys. The wastage of protein substance ds to be repaired if life and its activities are to be intained. The animal organism has no power of thesising its tissue-proteins from food components er than proteins and is therefore dependent upon se being supplied to it as ingredients of food.

OTEIN QUIREMENTS

Light has been thrown upon the protein or nitrogen requirements of the body by investigations on the amounts of protein nitrogen lost to the body under certain well defined ditions. These conditions are essentially that the contains no protein of any sort and that the individual erimented upon should have undergone a period of olute starvation so as to ensure that the digestive tract ompletely emptied of any food material. The loss of tein from the system under these conditions is calcu- d from the amount of nitrogen excreted by the kidneys trea, uric acid and its allies, which amount is converted average tissue-protein by use of the coefficient 6. 25.

In the case of a man of 11 stone the nitrogen loss is abo
3 grams per day, which corresponds to a basal prote
metabolism of about 18·75 grams. Reckoning the r
placement value of food protein at 50 per cent.—that is
parts of food protein are required to replace one pa
of body protein—the minimum amount of food protein
be eaten per day by a man should be 37·5 grams of firs
class or tissue-replacing proteins.

In reckoning the proper quantities of food protein
regard must also be had to the class of the protein, wheth
it is of such a nature as to replace completely in kind th
tissue proteins wasted, or whether it is in any way or
any degree deficient in this respect. The grou
of adequate proteins, the so-called first-class protei
are such as yield on digestion those five, and possibl
six, amino-acids from which alone the structu
of protoplasm and its chief derivatives in the tissues can b
completely built up : these proteins are chiefly of anim
origin, but a few are derived from plants. The secon
class or inadequate proteins lack one or other of thes
essential amino-acids and do not suffice of themselves t
replace wholly tissue wastage : they are mainly of vegetab
origin, although some of the animal proteins, such a
gelatin, fall into this group (see page 162).

While some 37·5 grams of first-class proteins alone ar
fully competent to balance normal wastage of tissue it
yet agreed that the daily amount of food protein should b
made up to some 100 grams. The remaining 62 grams ma
be either wholly second class proteins or mixed secon
class and first class. It chances that in large measure th
first class proteins, such as those of butchers' meat, ar
more expensive than the second class vegetable protein
but if care is taken in shopping, buying foods in season an
therefore in abundance, fresh and cheap, there need not b
much difference in price between the two classes.

Those who can afford a good table or who, like soldier
have it provided for them have much larger quantities o
first class proteins than the minimum of 37 grams per day
for example, the Army Ration of peace time works out a
62·7 grams of first class proteins. The British Medica

ociation Committee expressed the opinion that some-
ng between 37 and 62·7 grams would meet the case of
average person, and suggested 50 grams as a con-
ient figure, leaving the rest of the protein ration of 100
ms to be made up of lower grade vegetable proteins.

Dietaries have been recommended as fully practical, if
also preferable, which contain much less protein than
standard now established for this country, viz. 100 grams
h of protein and fat, and 500 grams of carbohydrate,
h an available energy value of 3,000 calories. Dr.
Hindhede questioned whether so much protein was
essary, for he himself lived and brought up a family on
liet containing about 67 grams total protein, mainly
getable. Country people in Europe to all appearance
ive on diets with even less protein. Numerous experi-
nts of long duration have proved that perfect health
be maintained on small quantities of protein, as on
ts of potatoes and fat, or of coarse oatmeal bread, or
whole oats with sugar and considerable quantities of
getable and fruits. A 60 to 70 gram protein diet could
built up of 500 grams of coarse oatmeal bread, 25
ms butter, 100 grams margarine, 500 grams potatoes
d 100 grams whole barley meal. Such a diet would
ntain an abundance of all the vitamins and be sufficient
mineral salts.

CHAPTER IV.

REGULATIVE OR PROTECTIVE FOODS.

The history of the science of nutrition so far may be roughly divided into three distinct periods, according to the particular nutritive constituent that has been stressed as being of primary importance. The first period recognised the significance of the energy-content of food, and calories were regarded as the proper, if not sufficient, measure of food for a system that was a sort of heat engine. The second period was marked by the emphasis laid upon the amount of protein in the food, for this was recognised as the essential basis of the building and repair of tissue. As knowledge increased, emphasis was shifted somewhat from proteins as a group to proteins divided into two classes, the first class and the second class, or more strictly to the amino-acids into which they are broken in the process of digestion and out of which the various tissue proteins are built. The third, and more recent period, while yet maintaining a proper regard for the importance of the calorie-foods and flesh-forming foods, has seen the development of an understanding of the essential part played in the economy of life by the so-called protective foods, chiefly the vitamins and certain minerals. Within this period emphasis was first largely laid upon the importance of the various vitamins to healthy life, and it has only been of quite recent years that the scarcely less importance of particular mineral elements, some like calcium in quantity and others like copper in microscopical amounts, has been realised.

These two classes of protective foods, vitamins and minerals, differ essentially from the other types of energy and tissue foods in that comparatively small, if not minimal, quantities are of significance in the nutritive and metabolic processes of the system. Only microscopical quantities of any of the pure vitamins would seem to be required at any one time for the maintenance and correct balance of

etabolism in so far as it is dependent upon them. These uantities are indeed so small that the strictly quantitative easurements of the balance are not delicate enough and source is had to a special technique of qualitative assess- ent by way of experiments on laboratory animals. In the rly days of vitamin research it seemed to many observers at the vitamins had no real existence but were either gments of the imagination or matters of intellectual ith on the part of their discoverers. We now know much tter, for they have been shown to be substances of finite chemical structure, many of them have been nthesised in the laboratory, and some have become ticles of commerce. Similarly, mere traces of certain inerals, needing the spectroscope for their detection in od, have proved to be absolutely essential to life.

tamins The vitamins were at first conveniently distinguished alphabetically as "A", "B" roup, "C", "D" and "E", etc. As their chemical mposition and structure are being proved, leading some cases to synthesis in the laboratory and in a few manufacture on a commercial scale, they are coming be known by more appropriate names.

Each of the several vitamins is distinguished by the part plays in maintaining the normal and healthy performance the tissues of particular functions or groups of functions: s absence or deficiency results in a profound disturbance the chemical reactions in a structure, which is made ident as a state of ill-health or, when extreme, as a ficiency disease. An outstanding feature is that ceedingly small quantities of one or other of these bstances suffice to correct the disease related to its sence. The purpose of the vitamins in the economy the system is quite evidently not to supply either energy substance. It would appear that they act as initiators stimulators, or even retarders, of chemical actions in ich other substances are engaged in measurable antities, and after the manner of catalysts they them- ves undergo, in contrast, little or no change of nature or uantity.

The different vitamins or rather their deficiencies, a associated with definite pathological disorders. Thus la of the vitamin A shows itself in certain types of eye disea and in faulty teeth. One of the B Group, B_1, wh deficient in the food of peasants in the tropics who subs largely on polished rice, is related to the disease beri-be while another, Riboflavin, is found to play an importa role in growth. Vitamin C, which is found in fresh fr and vegetables, prevents scurvy, and generally ensures healthy skin. Vitamin D is found in butter and eggs, a more abundantly in halibut and cod liver oils, and wh supplied the system together with calcium salts preven rickets.

Plant life is the primary source of most, if not all, of t vitamins; a fact which indicates that a properly balanc diet should include a fair quantity of such items as salad greens and vegetables, as commonly understood. But is not enough to depend upon one or two plant produc only if complete freedom from deficiency disease is sough No single plant member or product contains all the vitamin The distribution of these substances in the tissues of t allied species of plants or even of different organs of t same plant is capricious. Thus it is only in the frag silver skin that is removed when rice is polished that B_1 found, and not in the far more considerable mass of t grain as eaten. Vitamin E is very largely restricted to t the oil found in the germ or embryo of wheat and oth cereals, and for all practical purposes is absent from whi flour. While lemons among citrus fruits are especial rich in vitamin C, limes are a very inadequate sourc Tomatoes, fresh and tinned, are unusual among fruits containing in various abundance most of the common vitamins, but grapes are an inadequate source of any.

Among animal sources of vitamin D fish oils both in t flesh and livers are the richest. This vitamin is produc within the body by the action of the shorter rays of t sunlight upon the fat immediately beneath the skin, during sunbathing. It has also the advantage of bei stored within the system, and so available for a long tim

er supply or manufacture. Most other vitamins are itive and need to be continually ingested by way of table foods if good health is to be maintained. The portance of a sufficient supply of vitamins in both variety d dosage cannot be easily exaggerated, but the emphasis w being laid on particular processed products may be ch discounted in family budgeting as long as fresh fruit d vegetables in some variety are regularly eaten, and ercise in the fresh air and sunshine made a practice. It nfortunate that those who most need these protective ds, the poorer folk of the congested areas of our large vns, cannot, or in any case do not, spend enough on eens and fruit. Living in gloomy quarters and in oky atmospheres, they are peculiarly liable to develop various deficiencies in health and frame usually rected by vitamin D.

od Minerals

The food minerals comprise a second group of protective or regulative foods, d like the vitamins have proved to be absolutely essential the functioning of the system as a whole and in its several ts. The lack of any one of the food minerals shows itself in tone, general ill-health and, in the extreme, in some finite disease. Some food minerals, such as salts the elements calcium, sodium and potassium, are absorbed o the system in good quantity and the part they play is y evident. Calcium as calcium phosphate is an important gredient of bony tissue, while sodium and potassium osphates are of significance in maintaining the proper alinity of the blood. Iron and iodine although sorbed in much smaller quantities have equally evident s. There are other elements which are absorbed in croscopical, if not even spectroscopical, amounts and as it is shown by disorders following their absence m food, evidently play very important though obscure es in maintaining the health of the body.

Examples of this last group are the elements manganese, c, copper, cobalt and fluorine.

The various minerals found to be necessary to life are ually absorbed by the body from the water imbibed, or

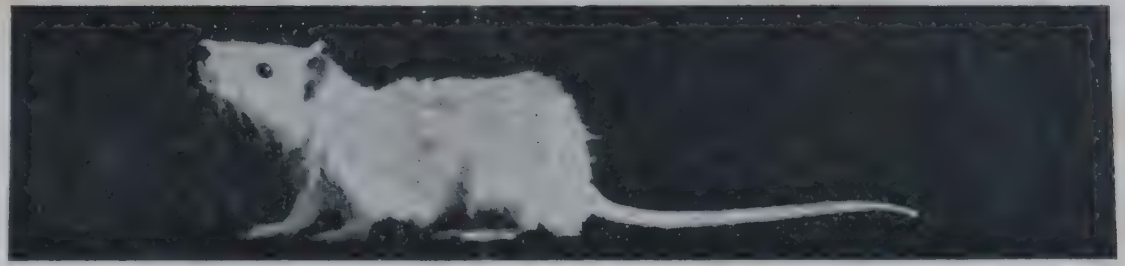


FIG. 1. This rat ate only meat, potato, bread and butter. He weighed 89 grams when six months old.

FIG. 2. His bones also show the effect of poor diet.

n the cell sap of the various animal or plant foods eaten. y constitute the ash of animal and plant tissues which ft after complete combustion. Milk and milk-pro- ts are appropriately rich in food minerals.

lere again is reason why a balanced diet should include ir proportion and variety of plant products, and why k should form the staple of very young children, and ed be never lacking from the diet at all ages. So that h vitamins and minerals should not be destroyed or in the process of cooking, the preparation of vegetables fruits for the table should be by quick heating, ferably by steaming rather than by boiling. Whenever s palatable and digestible, raw plant substance should eaten in preference to cooked food. Salads, greens and fruit are pre-eminently the sources of both vitamins minerals, and if bought fresh and in season the quate supply of these protective foods need not be ond the means of the poorest.

Much of the physical and mental inefficiency of the ool child and the adult alike is due to preventable ses at an early stage of life. Many of these causes are ely related to errors in diet due either to ignorance or lessness on the part of the housewife or, as in all too ny cases, to sheer lack of means to provide a sufficient proper food, and of facilities to prepare it. Inadequate nestic appliances and poverty joined with inefficiency improvidence result in grave deficiencies in the diet of oo large a section of the nation, and most disastrously ng the younger members of the classes where these ors chiefly operate. It is among the young that are he seeds of physical disabilities, which show themselves fter-life in a great variety of ways as anæmia, dental es, feebleness of growth, lack of energy, retardation, eptibility to infectious diseases, liability to rickets, erculosis and deficiency diseases generally.

FIG. 3. His twin brother ate plenty of milk and vegetables, besides meat, potato, bread and butter. He weighed 194 grams at six months.

he criteria of the proper diet of a growing child now
ablished are four in number.

a) The balance and totality of protein, fat and carbohydrate.

b) First class protein for repair and growth—chiefly animal protein.

c) Mineral matter, including iodine, phosphorus and calcium in organic combination, as in fresh fruit, vegetables, meat and milk.

d) Vitamins—protective against deficiency diseases.

he hope of a physically fit community is now seen to
largely upon the establishment of a sound food policy
t ensures the nutritional minima for all—children, men
women—each in their categories of age, circumstance
occupation. For the maintenance of morale and
rking efficiency upon which the prosperity and content-
nt of a nation depend good and sufficient food is
ential.

During the Second World War particular attention
paid to the feeding of the young and their mothers.
great increase in the production and consumption of
k and its liberal allocation to infants, school children
nursing mothers meant for fully one-half of the
tish population the consumption of first-class protein
the vitamins Riboflavin, A and D far beyond what
y had had previously. The free and subsidised
ribution of preparations of rose-hips, blackcurrants
oranges, and of cod-liver oil further guaranteed to
dren their requirements of vitamins A, C and D.
ool meals for children and communal meals for factory
other workers went far to provide the daily essentials
a well balanced diet. To all these were added ample
plies of vitamin B_1 and of calcium in National bread.

he result of this application of nutritional science to
feeding of the nation was a higher general standard
iving and of health and morale. The infant mortality
, which is largely determined by the food of the
ther, was the lowest on record and the rate of growth
children greater than ever before.

SECTION B.—NUTRIENTS.

CHAPTER V.

CARBOHYDRATES.

Carbohydrates. Formerly this group included o those compounds of carbon, hydrog and oxygen in which the latter two elements were combi in the proportions found in water (H_2O). Nowadays t term includes not only the majority of substances vegetable and animal origin which fall within this defi tion, but also a number of compounds in which hydrog and oxygen are not in the ratio as in water. Among t commonest members of the group are the different suga starches and celluloses, some soluble and others insolub Chemically, all carbohydrates are either such or ultimate yield aldehydes with the terminal group—CHO or keto with the penultimate group—CO, and are derivatives polyhydric alcohols. The simple sugars are the un from which the more complex sugars and other carb hydrates are derived by the development of linka among the unit molecules with the elimination of t elements of water by the process of "condensation Thus maltose may be regarded as built up of two molecu of glucose; sucrose of a molecule of glucose and one fructose.

$$2C_6H_{12}O_6 - H_2O = C_{12}H_{22}O_{11}$$

Glucose condenses to Maltose

$$C_6H_{12}O_6 + C_6H_{12}O_6 - H_2O = C_{12}H_{22}O_{11}$$

Glucose and Fructose condense to Sucrose.

By the reverse process of hydrolysis, water is taken by the molecules of the more complex carbohydrates a simpler carbohydrates and ultimately the simplest suga are produced. Thus starch yields finally on glucose; inulin only fructose; and sucrose, glucose a fructose equally.

rbohydrates are conveniently classed according as are composed of only one unit simple sugar molecule, vo such sugars, and of many, that is as (i) mono-harides, (ii) disaccharides, (iii) polysaccharides.

nosaccharides.

se, the simplest sugars, consist of one unit molecule with the al formula $C_nH_{2n}O_n$, where n is 3, 4, 5, 6, 7, 8, or 9; each ivision having its appropriate generic name, triose, tetrose, se, hexose and so on.

Triose	$C_3H_6O_3$
Tetrose	$C_4H_8O_4$
Pentose	$C_5H_{10}O_5$
Hexose	$C_6H_{12}O_6$
Heptose	$C_7H_{14}O_7$
Octose	$C_8H_{16}O_8$
Nonose	$C_9H_{18}O_9$

saccharides.

se consist of two units, with one molecule of water eliminatede ave the general formula $C_nH_{2n-2}O_{n-1}$, e.g., $C_{12}H_{22}O_{11}$, can , or sucrose, malt sugar or maltose, milk sugar or lactose. On lysis with dilute acid or suitable enzyme they split into the two onent simple sugar molecules.

olysaccharides.

se are multiples of more than two unit sugars and on hydro- split into disaccharides and ultimately into the molecules of mple sugar or sugars.

mmon examples are :

Monosaccharides.
Pentoses ($C_5H_{10}O_5$).
Arabinose and Xylose derived from pectins and gums.
Hexoses ($C_6H_{12}O_6$).
Glucose (Dextrose, Grape Sugar).
Fructose (Lævulose, Fruit Sugar).
Galactose.

Disaccharides ($C_{12}H_{22}O_{11}$).
Sucrose (Cane Sugar).
Maltose (Malt Sugar).
Lactose (Milk Sugar).

Polysaccharides $(C_6H_{10}O_5)_n$.
Starch.
Cellulose.
Glycogen (Animal starch)
Dextrin and Gum.
Inulin.

Enzymes. Within the organism the change to simple carbohydrate from a more complex brought about by the direct action of the living protoplasm, or by special products of the protopla the "ferments" or "enzymes." These appear to protein colloidal substances and to possess some of attributes of protoplasm. In addition to their power effecting hydrolysis, they operate in solution, of partic pH values, within fairly narrow ranges of temperatures, are "killed" by heat and poisons as prussic acid and chlo form. They can be extracted from solution by precipi tion with alcohol, can be dried and be dissolved again afterwards display their fermentative powers practica undiminished. A noteworthy feature of enzymes is th specific character; a particular enzyme is able to upon one substance only or, at the most, one group closely similar substances. The relation between enzyme and its substrate has been compared to that o key to a lock. The commonest enzymes affect carbohydrates are:—

Invertase, hydrolysing Cane Sugar to Glucose a Fructose.

Maltase, hydrolysing Malt Sugar to Glucose.

Diastase, hydrolysing Starch to Dextrin and Gluco

Another enzyme, zymase, secreted by yeast and effecti alcoholic fermentation of glucose to alcohol and carb dioxide, differs from most enzymes in carrying through t chemical changes without hydrolysis.

(i) The Monosaccharides.

These sugars are all soluble in water giving swe solutions. When gently heated dry, they first melt, th caramelise—the colour gradually darkening from a pa yellow to a dark red—and on further heating give water and thick acrid fumes, followed by charring, a finally leave a shiny black coke. Like all aldehydes a ketones, they are reducing agents, and most of the tests depend upon this fact. They form red precipita of cuprous oxide, Cu_2O, when their solutions are heate with alkaline copper sulphate, or Fehling's solution.

hling's solution is usually made of two separate ions—Solution A of pure copper sulphate and ion B of Rochelle salt (sodium potassium tartrate alkaline with caustic soda). The cupric hydrate, upric oxide, that usually appears when caustic soda ated with copper sulphate solution, is reduced by the r, and comes down as red cuprous oxide.

$$2CuO + \underset{\text{(Aldose)}}{R.CHO} = Cu_2O + \underset{\text{Acid}}{R.COOH}$$

mmoniacal silver nitrate solution (which may be rded as containing silver oxide (Ag_2O)), with a few s of solution of either glucose or fructose deposits arming a mirror of metallic silver on the inside of a tube. Glucose may be recognised by such tests in the s of fruits, honey, certain vegetables, as onions, and e urine of diabetics.

ose ($C_6H_{12}O_6$ or $CH_2OH(CHOH)_4CHO$) is found in es and raisins—hence its popular name of grape sugar. lution of the sugar placed in the tube of a polarimeter en to turn the plane of polarisation to the right, so it is said to be dextrorotatory; hence the third dextrose. It is an aldehyde sugar or an aldose. It ade on an industrial scale as corn syrup or glucose by ydrolysis of maize starch which is effected by heating latter for a while with dilute sulphuric acid. It allises from alcohol or from concentrated water ion as granulated grape sugar. It is readily soluble ater, and is sweet, but not so much as cane sugar er cent.), for which it is used as an alternative in the per sorts of sweets and jams. It ferments with yeast g alcohol and carbon dioxide. Glucose is used nsively in place of malt in the brewing of beer.

$$\underset{\text{Glucose}}{C_6H_{12}O_6} \xrightarrow{\text{Zymase}} \underset{\text{Alcohol}}{2C_2H_5OH} + \underset{\text{Carbon dioxide.}}{2CO_2}$$

ong as no impurities are introduced into the final uct from the sulphuric acid used for hydrolysis, corn o and commercial glucose are safe foods.

Glucosides are peculiar compounds of glucose, either in sin molecules or in more, with a variety of other groups. Examples amygdalin, sinigrin and salicin which on hydrolysis by spec enzymes yield various components. Amygdalin found in bit almonds is decomposed by its accompanying enzyme emulsin i glucose, benzaldehyde and prussic acid.

Emulsin.

$$C_{20}H_{27}O_{11}N + 2\,H_2O = 2C_6H_{12}O_6 + C_6H_5 \cdot CHO + HCN$$

Sinigrin is found in mustard seeds and on hydrolysis by myro breaks up into glucose, potassium bisulphate and mustard oil

$$C_{10}H_{18}NS_2O_{10}K = C_6H_{12}O_6 + KHSO_4 + C_3H_5N : C : S$$

Salicin yields glucose and salicylic alcohol.

Fructose ($C_6H_{12}O_6$ or $CH.OH(CHOH)_3 \cdot CO \cdot CH_2OH$), found widely distributed with glucose in fruits, hon and in jam. It is the sweetest of all the sugars. It diffe from glucose in being a ketone, and more evidently l turning the plane of polarisation to the left, hence i other name lævulose. Like glucose it ferments wi yeast and forms alcohol and carbon dioxide gas. Whe cane sugar, a disaccharide, is hydrolysed it yields bo glucose and fructose; the former dextrorotatory an the latter lævorotatory, but the power of the fructo being higher than that of the glucose, on the balance th mixed sugars are lævorotatory and the original ca sugar which is dextrorotatory is said to be "inverted and the mixture of glucose and fructose is known invert sugar.

$$\underset{\substack{\text{Cane Sugar}\\ \text{Dextro.}\\ (\alpha)\ D = +66^\circ}}{C_{12}H_{22}O_{11}} + H_2O = \underbrace{\underset{\substack{\text{Glucose}\\ \text{Dextro-}\\ (\alpha)\ D = +55^\circ}}{C_6H_{12}O_6} + \underset{\substack{\text{Fructose}\\ \text{Lævo-}\\ (\alpha)\ D = -92^\circ}}{C_6H_{12}O_6}}_{\substack{\text{Invert Sugar}\\ \text{Lævo}\\ (\alpha)\ D = -39^\circ}}$$

Galactose is of significance only as a product with gluco of the hydrolysis of the disaccharide, milk sugar.

(ii) The Disaccharides ($C_{12}H_{22}O_{11}$).

This group includes three common sugars: (i) ca sugar or sucrose: by far the most important natur

r ; (ii) malt sugar, or maltose, and (iii) milk sugar or
se. These all have the common simple formula—
$_{22}O_{11}$—but differ somewhat in their properties,
nical and physical alike, and fundamentally in the
ngement of the component elements and groups
in their molecules.

nese disaccharides may be regarded as condensation
lucts of two unit molecules of hexose sugars, which
regenerated by the reverse process of hydrolysis.
e sugar is built of a molecule of glucose and one of
tose ; malt sugar, of two molecules of glucose and
sugar of a molecule each of glucose and of galactose.
e sugar differs from malt sugar or milk sugar in
aining neither an aldehyde nor a ketone group and
efore in not being able to reduce either Fehling's
tion or ammoniacal silver nitrate, i.e., it is a non-
ucing sugar. When, however, cane sugar is hydrolysed
so converted into a mixture of glucose and fructose,
product acts as a reducing sugar. Before cane sugar
be fermented by yeast it must first be inverted by an
me, invertase, present in yeast.

e Sugar ucrose. This, the commonest of sugars occurs widely in nature ; in ripe sugar cane (15 to 20 per cent.), in beet root (7 to 17 cent.), in maple sap (2 to 3 per cent.) and in a variety pe fruits, e.g., strawberry (5 to 6 per cent.), pineapple per cent.). Honey contains much cane sugar and rt sugar and it was probably the first sugary material for sweetening purposes and for making an alcoholic k, mead. There are occasional references in Domesday k to bee gardens on the edge of the New Forest, otless maintained as a source of honey.

is from sugar cane and beet root that by far the test quantity of commercial sugar is manufactured, ormer cultivated mainly in the tropics and the latter mperate countries. (For industrial preparation of sugar see page 297.)

Malt Sugar or Maltose. This sugar is found in malt, or the you germinating grain of barley, wheat or oa and is formed by the action on the star of the endosperm by diastase, which is secreted by t outer layer of the scutellum of the germ or embry Malt is the primary substance from which beer is mad After damp grains of barley have been allowed to germina in the dark for a sufficiently long period, at a suitab temperature, they are dried and killed by being heated a kiln over hot fumes from coke. When the malt boiled with water the sugar dissolves out and forms sweet solution—wort—from which maltose may obtained by evaporation and crystallisation.

Maltose is not so sweet as cane sugar. It is dextr rotatory to a much higher degree ($(\alpha)D = +137°$) th glucose, lactose or sucrose. It reduces Fehling's solutio When hydrolysed, either by boiling with dilute miner acids or by the action of its specific enzyme maltas maltose yields only glucose.

Maltose ferments with yeast only after it has be converted into glucose by the action of the maltase whi is secreted by yeast in addition to zymase, in much t same way as sucrose is made fermentable after the acti of invertase or sucrase which also is among the produc of yeast.

$$\underset{\text{Maltose}}{C_{12}H_{22}O_{11}} \xrightarrow{\text{Maltase}} \underset{\text{Glucose}}{2C_6H_{12}O_6} \xrightarrow{\text{Zymase}} \underset{\text{Alcohol}}{4C_2H_5OH} + 4C$$

Milk Sugar or Lactose. Milk sugar is found in milk in t appreciable amount of 3 to 6 per cen It is fairly readily soluble in water and mildly sweet to taste. It reduces Fehling's solution being an aldose sugar. On hydrolysis with dilute aci or the special enzyme lactase, it splits into a molecule glucose and another of galactose.

$$\underset{\text{Lactose}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow{\text{Lactase.}} \underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{Galactose}}{C_6H_{12}O_6}$$

ilk sugar is not affected by yeast, for the enzyme ded to hydrolyse it is missing in yeast. Milk sugar is, ever, affected by lactic bacteria, with the formation actic acid, to which the acidity of sour milk and the ding of casein are due. (See page 218.)

$$\underset{\text{Lactose}}{C_{12}H_{22}O_{11}} + H_2O = 4\underset{\text{Lactic acid}}{C_2H_5O \cdot COOH}$$

(Lactic bacteria.)

The Polysaccharides $(C_6H_{10}O_5)_n$.

he commonest polysaccharides, starch and cellulose, found abundantly in plants: the former as a food e and the latter as the material forming the cell walls. cogen, "animal starch," is a food store in animals nd in the liver and muscles. Dextrin or British Gum product of the hydrolysis of starch on the way to plete hydrolysis as malt sugar. Inulin, another saccharide, is narrowly limited in its occurrence in tubers of artichoke, dahlia and the like.

hese polysaccharides are built up of varying but high nbers of hexose units, into which they are ultimately lved by continued hydrolysis, either by boiling with te mineral acid or by the action of suitable enzymes.

hus :—

Polysaccharides.			*Monosaccharides.*
Starch —>	Dextrin —>	Maltose —>	Glucose
with Diastase	with Diastase	with Maltase	
Cellulose——————>			Mannose & Galactose
	with Cytase		
Glycogen ——————————>			Glucose
	with Glycogenase		
Inulin ——————————>			Fructose
	with Inulase		

rch $(C_6H_{10}O_5)_n$.

tarch is widely distributed in plants, and is found nly in storage form in roots, tubers, stem pith and endosperm. It is the commonest reserve form of bohydrate. It is synthesised in leaves by the

process of photosynthesis or carbon assimilation, fro carbon dioxide gas absorbed from the atmosphere throu the leaf stomata and the water taken up from the s by the roots and transmitted to the leaves by the vascul system. This synthesis takes place only when the c protoplasm is accompanied by chlorophyll and in t presence of sunlight. Oxygen is liberated, usually equ in volume to the carbon dioxide absorbed.

Starch is insoluble in cold water, but when warmed wi water the wall of the grain, which is formed of starc cellulose, bursts and liberates the contents, granulos which readily dissolve. The granulose may be precipitate from solution by alcohol as an amorphous powder know as "soluble starch." Starch dissolves in water to for a colloidal solution which on cooling coagulates as a jell This gelatinous paste is largely used in laundry practi for stiffening various goods. In the baking of bread portion of the starch of the dough gelatinizes under t circumstances of moisture and moderately high temper ture. In toasting bread some starch is converted in dextrin. Industrial starch—as sago starch, farina (pota starch) and wheat starch—is much used as sizing materi for strengthening the warp threads of cotton befo weaving.

Starch is obtained from tubers of potatoes, roots tapioca and grains of wheat, maize and rice by crushi and maceration with water and allowing the milky liqu to deposit it as a paste, which after further washing allowed to dry slowly.

Source.	*Starch per cent. dried substanc*
Potato tubers	72–84
Wheat grain	66–72
Maize grain	68–72

Starch is composed of microscopical grains which ha definite shapes and sizes according to the plant speci from which they have been derived, so that in practi the different starches can be readily recognised a adulteration detected.

lulose. Cellulose is widely distributed throughout the plant kingdom, as the chief constituent cell walls. The middle lamella which is the layer t formed when a cell originates in the course of cell ision consists not of cellulose but of pectin, which ugh related to cellulose, yields on ultimate hydrolysis ntose sugars. It is upon the middle lamella that pure lulose is deposited, but after a while, particularly in od cells and vessels, this is modified by union and usion with lignins—a group of gums and resins yielding ntoses. Soft woods like spruce yield some 55 per cent. re cellulose, and hard woods like oak only 35 per cent., nce the use of the former as a source of commercial lulose.

Another form of compound cellulose is cutin. This ms the outermost layer of the epidermis of the leaves l stems of many plants, and like the suberin of corky sue is fatty in character and impervious to water and istant to the usual agents of decay.

Normal cellulose is particularly pure, and forms the re of cotton (89 to 91 per cent.), flax and hemp (72 per t.) and on hydrolysis yields finally only glucose. mi-cellulose found in certain seeds, as peas, beans and fee, hydrolyses more easily than normal cellulose but fers from it in yielding on hydrolysis other hexose ars, mannose and galactose, as well as some pentose ars. Cellulose and hemi-cellulose are not digestible the human body and are unavailable as food.

The simplest formula of cellulose is $(C_6H_{10}O_5)_n$; the ue of n is unknown, but must be high for the molecular ght is estimated as of the value of 300,000 units. s remarkably inert to most reagents, whether water, nte acids or alkalies under ordinary conditions, but solves readily in Schweitzers solution, made by dissolv- precipitated copper hydrate in ammonium hydrate. lulose is re-formed in a hydrated state by neutralisation his solution with acids. This reaction is the basis of manufacture of cuprammonium cellulose rayon. lulose purified from cotton linters or waste, or from wood, is dissolved by other reagents to form ultimately

other varieties of rayon; thus, by xanthic acid in t preparation of viscose, by nitric acid in the preparati of nitro-cellulose and collodion, and by a mixture of ace and phosphoric acids in the preparation of cellul acetate rayons.

The behaviour of cotton cellulose towards alkalies peculiar. Below 10 per cent. concentration of caus soda there is no reaction; between 18 and 28 per cent hydro-cellulose is formed with quite distinct chemi and physical properties. Cotton is then said to "mercerised"; it has become cylindrical, thicker a more compact, and being also smoother and transluce has a silky lustre. On drying, the fibre shrinks to abo three-quarters of its original length and increases near 70 per cent. in strength. If drying is allowed und tension so that no shrinkage takes place the silky lust is retained, but the increase in strength is only abo 33 per cent. Mercerised cotton, or hydro-cellulo behaves towards dyes much as does silk.

Cellulose being a substance containing alcohol hydroxyl groups, in sets of three for each hexose un readily interacts with suitable strengths of mixed nit acid and sulphuric acid to form nitrate esters, known nitro-cellulose. Gun-cotton is one of the higher nitrates and probably a tri-nitrate ($C_6H_7O_2(ONO_2)_3$) (13·4 p cent. nitrogen); collodion is a lower nitrate (C_6H_7 $(OH)(ONO_2)_2$ 12·6 per cent. nitrogen) and pyroxylin is group of the lower nitrates ($C_6H_7O_2(OH)_2(ONO_2)$ (10 or 12·2 per cent. nitrogen).

Dextrin (British Gum) and Gums $(C_6H_{10}O_5)_n$.

Dextrin is usually found associated with cellulose, which it would appear in most cases to be a derivati as a result of an early stage of hydrolysis brought abo by suitable diastatic enzymes or organic acids. Progre sive action of diastase on starch yields various dextrin which while agreeing in being soluble in water, and reducing Fehling's solution, yet differ from starch an among themselves in the colour compounds they for

iodine: one variety giving red colour (erythro-rin) and others no colour at all. Ultimately dextrin rolyses to maltose.

extrin or British Gum is prepared commercially from ch by heating it below 100°C. to 125 C. with mixed te hydrochloric and nitric acids, or at lower tempera-s about 40 C. by subjecting it to the action of malt acts. When dried it is colourless or slightly yellow, morphous glassy substance, readily soluble in water ive a mucilage, which has many purposes, largely acing true gums, on postage stamps, envelopes, labels, There is a certain amount of dextrin in the crust of d and in the skin of rice pudding and other cooked chy foods, as well as on the gloss of ironed starched dry goods.

he vegetable gums, like gum arabic, cherry gum, d gum, are soluble in water and produce on hydrolysis dilute mineral acids, pentose sugars such as arabinose xylose as well as hexoses as galactose.

$$(C_5H_8O_4)_n + nH_2O = nC_5H_{10}O_5$$

Wood gums. Xylose

extrin, being related to starch, yields under such umstances the same hexose sugar, glucose.

ogen or Animal ch $(C_6H_{10}O_5)_n$. This polysaccharide has the same empirical formula as that of starch and cellulose and like them has in robability a very complex molecule built up of many se units. It is found in the liver (10 per cent.) and e muscles (2 per cent.) of animals, most probably there fuel reserve from which energy may be derived equired. It is a white powder readily soluble in water gives a reddish brown or port wine colour with iodine tion. On hydrolysis it splits first into dextrins, then tose and at last yields glucose. The ptyalin of the va quickly converts it into maltose. Within the body its hydrolysis is brought about in all probability er by the direct action of the cell protoplasm or by a ific enzyme. During muscular contraction, glycogen,

or its ultimate basic substance glucose, is conver
without the absorption of oxygen into lactic acid C_3H
with the liberation of energy. (See page 156).

Inulin $(C_6H_{10}O_5)_n$.

This is a polysaccharide which is found dissolved
the cell sap of the tubers of dahlias and artichokes, fr
which it is separated as a white powder either by evapo
tion or by precipitation with alcohol. The powder
readily distinguished from starch by not giving a
colour with iodine. It is hydrolysed by a spec
enzyme, inulase, and yields, as also by the action
dilute acid, only fructose.

$$(C_6H_{10}O_5)_n \xrightarrow{\text{Inulase.}} C_6H_{12}O_6$$

Inulin — Fructose.

EXPERIMENTS ON SUGARS.

MONOSACCHARIDES, e.g., glucose (dextrose), and fructose (lævulo
DISACCHARIDES, e.g., cane sugar (sucrose), malt sugar (maltose),
milk sugar (lactose).

Experiment 1.

Preliminary Tests.

Examine samples of the above soluble carbohydrates and n
their degree of sweetness, solubility in water, reaction to litmus
case of crystallisation.

Experiment 2.

To show the presence of a Soluble Carbohydrate.

MOLISCH'S TEST.

Prepare 10 per cent. solutions of the above soluble carbohydr
and put a few ccs. of each into test-tubes. Add a few drop
a 10 per cent. solution of α-naphthol in alcohol to each. Shake
and then pour a little concentrated sulphuric acid down the sid
the sloping test-tubes so that it sinks to the bottom without mix
with the rest of the solution. Allow the test-tubes to stand.
soluble carbohydrate should give a purple or pink colouration
the junction of the two layers.

Experiment 3.

To test the reducing powers of a Soluble Carbohydrate.

(a) FEHLING'S SOLUTION.

To a neutral solution of the soluble carbohydrate in a test-t
add an equal volume of Fehling's solution No. 1 and Fehl
solution No. 2. Place in a beaker of water and warm gently.
formation of a reddish brown precipitate indicates the presence
reducing sugar.

(*b*) Barfoed's Reagent.

ces of a neutral solution of the soluble carbohydrate add an olume of Barfoed's reagent prepared by dissolving 13·3 gms. ral crystallised cupric acetate in 200 cc. of 1 per cent. acetic Place in a beaker of boiling water for a few minutes. The ion of a reddish brown precipitate of cuprous oxide will e the presence of a reducing sugar. Provided the heating continued for more than a few minutes only monosaccharides ing about this reduction. If the heating is continued for ngth of time disaccharides will be hydrolysed and will then the cupric acetate to cuprous oxide.

Experiment 4.

ow that Soluble Carbohydrates can diffuse through moist Animal Membranes.

a piece of pig's bladder over the mouth of a thistle funnel. uce some of the carbohydrate solution by means of a pipette ace in a beaker of water in an inverted position. Leave for ours. At the end of this time note the level of the solution thistle funnel and test the water in the beaker for the presence ohydrate by some suitable test.

Experiment 5.

t whether the Soluble Carbohydrate is Fermentable by Yeast.

e pieces of yeast about the size of a pea in a series of boiling and fill the tubes to the brim with 5 per cent. solutions of the s soluble carbohydrates. Fit the boiling tubes with one-rubber stoppers and glass tubes bent twice at right angles o have one short limb and one long limb. Attach the short o the rubber stoppers. Invert the tubes in a large beaker of (see diagram) and heat to between 35°C. and 40°C. for several Any carbon dioxide evolved will collect at the ends of the and the volumes in the various tubes can be compared. Test ter in the tubes for alcohol by the iodoform test.

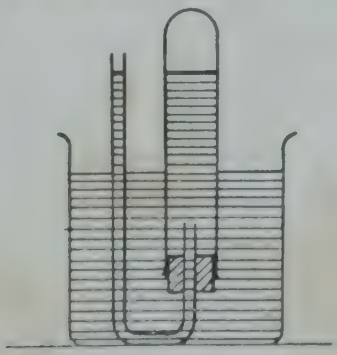


Fig. 5. Action of yeast on soluble carbohydrates.

Experiment 6.*

To Test for the Formation of an Osazone.

Dissolve about 0·2 gms. of phenylhydrazine hydrochloride
about 0·4 grms. of sodium acetate in 10 ccs. of water. Filter
solution if it is not quite clear and add a few drops of acetic
to the filtrate. To this solution add about 5 ccs. of a 2 per
solution of the carbohydrate, plug the tube with cotton wool
heat in boiling water in a beaker for half an hour to an hour.
osazone formed will separate out as a yellow precipitate whi
more or less crystalline in character. Examine the osazone u
the microscope. If it proves to be amorphous dissolve the pre
tate in a small quantity of warm alcohol, add an equal vol
water and then boil to drive off the alcohol. The osazone sh
separate out in a crystalline form on cooling.

Glucosazone forms fine needle-shaped crystals in cluster
sheaves. Lactosazone forms fine needle-shaped crystals gro
together in a burr-like formation. Maltosazone forms b
needle-shaped crystals grouped together in rosettes.

*Experiments starred thus may be postponed.

Experiment 7.

To show the action of Dry Heat upon Soluble Carbohydrat

Heat a sample of the carbohydrate gradually in a dry test-t
Note the ease with which the carbohydrate melts, the charring
reaction to fumes and the character of the fumes evolved.

Experiment 8.

**To show the effect of Concentrated Sulphuric Acid upon So
Carbohydrates.**

To a quantity of the carbohydrate in a test-tube add concentr
sulphuric acid. Note any immediate change and any fu
change which takes place on standing.

Experiment 9.

**To show the effect of Concentrated Caustic Soda upon So
Carbohydrates.**

Repeat the previous experiment using concentrated caustic
solution in place of concentrated sulphuric acid. Compare eff

Experiment 10.*

**To carry out the Resorcinol Test for Carbohydrates conta
Ketone groups.**

Mix equal volumes of the carbohydrate solution and d
hydrochloric acid. Add a few drops of resorcinol solution and w
Note the red colour and brown precipitate. This test appli

ydrates which either contain a ketone group or are capable ding one. Work with lævulose and sucrose.

Experiment 11.

ry out the Lead Acetate Test for Dextrose, Lactose and Maltose.

pare solutions of the three above sugars of about 10 per cent. th. Add 5 per cent. lead acetate solution to each and heat ling. Add ammonia and warm. Notice the formation of a olouration.

Experiment 12.

ow the effect of the addition of Calcium Hydroxide to solutions of Carbohydrates.

solutions of sucrose, dextrose, lævulose and any other soluble ydrate add an equal volume of lime-water. Note the . Explain your results and note the uses to which this on is put.

Experiment 13.*

To estimate the purity of a sample of Sugar.

two principal methods used for the quantitative analysis of s are based upon their power of reducing Fehling's solution n their optical activity. Since the polarimeter necessary for etermination of optical activity is not usually available the ng's solution method is described here. The principle of the od is as follows. Exactly 5 ccs. of Fehling's solution No. 1 ccs. of Fehling's solution No. 2 are mixed together and the r salt is completely reduced to cuprous oxide by heating to g with a measured volume of sugar solution. The exact weight gar required to do this is known and is expressed as the *per-reducing power*" of the sugar. Thus the strength of the solution can be calculated from the volume of the solution red to bring about the reduction.

copper reducing powers of some of the common sugars are llows :—

Dextrose, 0·5 gm.
Lævulose, 0·05 gm.
Invert Sugar, 0·05 gm.
Sucrose (after inversion), 0·0475 gm.
Lactose (anhydrous), 0·0642 gm.
Maltose, 0·0807 gm.

EPARATION AND STANDARDISATION OF FEHLING'S SOLUTION.

ution No. 1 contains 69·278 gms. of pure crystallised $CuSO_4$ dissolved in water and made up to 1 litre.

ution No. 2 contains 346 gms. of Rochelle salt (sodium potassium ate) and 142 gms. of caustic soda dissolved in water and made 1 litre.

When the two solutions are mixed (which should only be d immediately before use) a clear deep blue solution is obtained. Rochelle salt present prevents precipitation of cupric hydro by the caustic soda.

For accurate work the Fehling's solution should be standardi Weigh out accurately 0·5 gm. of pure dextrose, dissolve in dist water and make up to 100 ccs. Fill a burette with some of solution. Pipette out into a conical flask 5 ccs. of Fehling's solu No. 1 and 5 ccs. of Fehling's solution No. 2, dilute with 30 cc water and heat to boiling.

Run in the dextrose solution from the burette in small quant at a time and boil and shake between each addition. When reduction appears to be nearly complete and the blue colour almost disappeared use potassium ferrocyanide as an out indicator in the following manner: Filter a few drops of the solu through a filter paper without funnel on to a clean tile. Acidify a drop of acetic acid and touch with a glass rod dipped into fre prepared potassium ferrocyanide solution. The formation brown colouration of cupric ferrocyanide is an indication of incomp reduction. Continue the titration until no brown colouratio given in this test. With practice the titration can be carried with accuracy without withdrawing any appreciable quantity the solution for determination of the end-point.

Theoretically 10 ccs. of the dextrose solution, i.e., 0·05 gm. sh be required for reduction of the Fehling's solution. Should result not be obtained on titration the exact amount of dext required for the reduction of the Fehling's solution should calculated or a factor for the solution may be employed.

Method—Determination of Sucrose.

Prepare a 1 per cent. solution of the sample of sucrose by dissol exactly 1 gm. in 100 ccs. of water. Measure 50 ccs. of this solu into a flask, add 5 ccs. of concentrated hydrochloric acid and on a water-bath for 15 minutes to invert the sucrose. Cool add sodium carbonate until the solution is alkaline. Pour in graduated flask and make up to 100 ccs. This solution now cont an amount of invert sugar equivalent to the amount of sucros 0·5 gm. of the sample of sugar taken.

The method is now the same as already described for the stand isation of the Fehling's solution. The volume of solution requ for complete reduction of 10 ccs. of Fehling's solution is equiva to 0·0475 gm. of sucrose. From this the weight of sucrose in 100 of the solution can be calculated and since 100 ccs. of the solu contains 0·5 gm. of the sugar taken, the percentage of sucrose be calculated.

In a determination of dextrose, lævulose or invert sugar i of course, unnecessary to carry out a preliminary inversion.

EXPERIMENTS ON STARCH.

Experiment 1.

Preliminary examination of Starch.

mine some ordinary laundry starch. Note the colour, taste, and feel. Is starch crystalline or non-crystalline ?

Experiment 2.

Microscopic examination of Starch.

pare microscope slides of various types of starch and examine the low and high powers of the microscope. Note the relative s and sizes of the starch grains and particularly the presence or ce of a hilum and striations.

Experiment 3.

To carry out the iodine test for Starch.

a test-tube half full of water add a few drops of a starch paste hake well. Add one or two drops of a solution of iodine in sium iodide solution. Note the intense blue colouration ced. Apply heat and notice that the blue colour disappears. nder the tap until the blue colour returns. Note the effects addition of alkali and acid to the blue colouration.

Experiment 4.

detect the presence of Starch in various food materials.

iodine test for starch is an extremely delicate test and may ed to detect the presence of starch in food materials. Prepare s with boiling water of potato, flour, rice, sago, tapioca, arrow- nd cornflour and test as described in Experiment 3.

Experiment 5.

o show that Starch is formed in green leaves of plants.

ce a leaf in boiling water for a few minutes to kill the living s (a lime leaf picked on a sunny day is suitable). Then the leaf in boiling methylated spirits on a water bath to t the green colouring matter, chlorophyll. When the colour racted wash the leaf in cold water and when cold dip it in solution. Wash it again, place it on white paper and note lour.

eat the experiment, with a plant, e.g., fuchsia, which has kept in the dark for several days. It is interesting to carry he same test with variegated leaves such as variegated privet variegated maple. What conclusions can be drawn from experiments as to the formation of starch in plants ?

Experiment 6.

To test the reaction of Starch Paste to Litmus.

With a glass rod place drops of starch paste upon blue an litmus papers. Is starch paste acid, alkaline or *neutral* ?

Experiment 7.

To test the solubility of Starch in cold and hot water.

(*a*) Cold Water.

Half fill a test-tube with cold water. Add a small quanti starch and shake well. Filter into a second test-tube and tes filtrate for the presence of starch by means of iodine solution. blue colouration is produced showing that starch is insolub cold water.

(*b*) Hot Water.

Half fill a test tube with cold water. Add a small qua of starch, shake well and heat to boiling. Filter into a se test tube and test the filtrate for the presence of starch by m of iodine solution. Is a blue colouration produced ?

Experiment 8.

To show the correct method of making a Starch Paste.

Place equal quantities of starch in two evaporating basins. the first into a cream with a small quantity of cold water. no cold water to the second. Now add equal quantities of bo water to each and stir until a paste is obtained. Compare two starch pastes produced and conclude as to suitability laundry purposes.

Experiment 9.

To examine a Starch Paste.

Prepare a starch paste of about 1 per cent. strength in a be and leave it to stand until it separates into a cloudy layer a clear layer. By means of a pipette take a sample from each and test them with iodine. Note the results and conclude as t reason for the separation into two layers.

Experiment 10.

To find the effect of boiling upon the structure of Starch Gr

Grate a piece of raw potato into cold water in an evapor basin. Pour the turbid liquid from the residue and allow it to s Pour off the liquid from the white sediment and examine a sa of the latter under a microscope. Make a starch paste o remainder of the white sediment and examine under a micros Compare the appearance with that of the raw starch grains conclude as to reason for the cooking of starch foods.

Experiment 11.

To illustrate the use of Starch for Laundry purposes.

ash five pieces of linen about 2 inches square in soap solution in cold water and then treat separately in the following ner :—

(*a*) Iron without starching.
(*b*) Dip into cold water, starch and iron.
(*c*) Dip into boiling water, starch and iron.
(*d*) Dip into boiling water, starch to which a little paraffin wax has been added and then iron.
(*e*) Dip into boiling water starch to which a little borax has been added and then iron.

mpare the appearance and feel of the pieces of linen after ng and conclude as to the suitability of the various methods for ent purposes.

Experiment 12.

o show that Starch is unable to pass through moist animal membranes.

e a piece of moist pig's bladder over the mouth of a thistle el and fill with a thin starch paste by means of a pipette. the funnel in an inverted position in a beaker of water and to stand for several days. At the end of this time test the r in the beaker for the presence of starch by means of the e test. Repeat the experiment using glucose solution instead arch paste and after the experiment test the water in the er with Fehling's solution.

te the bearing of your results on the digestion of starch foods

Experiment 13.

To show the effects of dry heat upon Starch.

ace a little dry starch in a crucible and heat gently. Note hanges which take place and compare them with those obtained e case of sugars.

Experiment 14.

To show the action of dilute acids on Starch.

epare about 200 ccs. of a thin starch paste about 1 per cent. gth in a beaker and add to it about 5 ccs. of concentrated uric acid. Heat over a small flame and watch carefully any ges in appearance. At intervals of about 5 minutes withdraw les by means of a pipette, neutralise then with caustic soda ion and test with iodine solution. Reserve the test-tube for arison. It will be noted that the colour produced with iodine ually changes until it becomes reddish brown. This is an

indication that the starch has been changed into dextrin continued heating the colouration with iodine almost or e disappears. At this stage the dextrin has been changed sugar. To show that a sugar has been formed, neutralise a f sample and test with Fehling's solution. If this test is suc try to identify the sugar by the formation of an osazone a examination under the microscope.

The changes taking place are :—

Starch	—>	dextrin	—>	maltose	—>	gluco
$(C_6H_{10}O_5)_n$		$(C_6H_{10}O_5)^n$		$C_{12}H_{22}O_{11}$		C_6H_1

Experiment 15.

To show the action of Malt Extract upon Starch.

Prepare a 1 per cent. starch paste in a beaker and add a malt extract by means of a glass rod. Stir the two together leave to stand for several hours. Then test a portion of the mi with iodine solution. No blue colouration will be produced, sh that the starch has been changed into something else. Te second portion with Fehling's solution. The production of a re brown precipitate indicates the presence of a sugar. This sug maltose formed from starch by the enzyme, diastase, present i malt extract. Prepare an osazone and identify it as that of ma by microscopic examination.

Draw conclusions as to the medicinal and digestive qualitie malt extract and malted foods.

Experiment 16.

To show the action of Saliva upon Starch.

Pour a little 1 per cent. starch paste into a small evaporating b and cover with saliva. Leave to stand in a warm place or w on a water-bath to 37°C. (blood heat) for about 20 minutes. T dilute with water and test samples with iodine (neutralise alkaline saliva with a little acid) and with Fehling's solution. enzyme, ptyalin, of the saliva hydrolyses the starch to malt The significance of this experiment should be obvious.

The experiment can be repeated using pancreatic extract inst of saliva.

Experiment 17.

To prepare a sample of Dextrin from Starch.

Cover a small quantity of starch in an evaporating basin w very dilute nitric acid. Heat the basin in an air oven to a tempe ture of 150°C. for some time. The starch changes into a colourl or pale yellow glassy substance. Dissolve a little of it in water a test it with iodine solution and Fehling's solution. It should g no blue colouration with iodine or reddish brown precipitate w

g's solution. (*b*) Heat a 10 per cent. starch paste with an volume of 50 per cent. sulphuric acid in a beaker until a when neutralised and tested with iodine solution gives no blue ation. At this stage, allow to cool and pour into methylated Dextrin is insoluble in alcohol and will be precipitated. e the precipitated dextrin by filtration and examine.

EXPERIMENTS ON CELLULOSE.

Experiment 18.

To investigate the properties of Cellulose.

cotton wool or shredded filter paper as pure cellulose and ith the following reagents :—

(*a*) Cold water.
(*b*) Boiling water.
(*c*) Cold dilute acids.
(*d*) Boiling dilute acids.
(*e*) Cold concentrated sulphuric acid.
(*f*) Boiling concentrated sulphuric acid.
(*g*) Cold caustic soda solution.
(*h*) Boiling caustic soda solution.

pare the resistance to attack by chemical reagents with that ch and note the importance of this resistance in the digestion cell walls of vegetables by enzyme action. What advantage ned for the cellular structure of vegetables as an ingredient of

CHAPTER VI.

FATS AND LIPOIDS.

Fats and oils- the former solid and the latter l
at ordinary temperatures—are widely distribute
plants and animals. They are compounds of the
and related acids with glycerol, and differ radically
the mineral oils which are hydro-carbons. Glycero
trihydric alcohol containing three hydroxyl (OH). g
and can therefore combine with one, two or three
basic acid radicals to form esters, which are distingu
as mono-, di- or tri-glycerides.

$$\begin{array}{l} CH_2OH \\ | \\ CH.OH \\ | \\ CH_2OH \end{array} + HOOC.R \longrightarrow \begin{array}{l} CH_2O.COR \\ | \\ CHOH \\ | \\ CH_2OH \end{array} + HOOC.R \longrightarrow \begin{array}{l} CH_2O \\ | \\ CHO \\ | \\ CH_2O \end{array}$$

Glycerol. Acid. A Mono-glyceride. A Di-glyce

$$\begin{array}{l} CH_2O.COR \\ | \\ CHO.COR \\ | \\ CH_2OH \end{array} + HOOC.R \longrightarrow \begin{array}{l} CH_2O.COR \\ | \\ CHO.COR \\ | \\ CH_2O.COR \end{array}$$

A Tri-glyceride.

The tri-glycerides of the higher fatty acids are t
most commonly occurring in the natural fats and
These differ from one another essentially in respec
the different fatty acids that are combined with
glycerol and of the different proportions of those
combined. When one acid only is concerned the glyce
is a simple one; such are tripalmitin, a compound
palmitic acid, $C_{15}H_{31}COOH$, with glycerol, tristearin
compound of stearic acid, $C_{17}H_{35}COOH$, with glyce
and triolein, a compound of oleic acid, $C_{17}H_{33}CO$
with glycerol, and tributyrin a compound of butyric a
C_3H_7COOH, with glycerol.

$CO.C_{15}H_{31}$ $CH_2O.CO.C_{17}H_{35}$ $CH_2O.CO.C_{17}H_{33}$ $CH_2O.CO.C_3H_7$

$O.C_{15}H_{31}$ $CHO.CO.C_{17}H_{35}$ $CHO.CO.C_{17}H_{33}$ $CHO.CO.C_3H_7$

$CO.C_{15}H_{31}$ $CH_2O.CO.C_{17}H_{35}$ $CH_2O.CO.C_{17}H_{33}$ $CH_2O.CO.C_3H_7$

mitin Tri-stearin Tri-olein Tri-butyrin.

more generally the fats and oils found in nature are not tri-glycerides but consist of one or more mixed glycerides in olecules of which more than one fatty acid is represented. se may be generally stated by the formula–

$$\begin{array}{l} CH_2O.COR \\ | \\ CHO.COR^{I} \\ | \\ CH_2O.COR^{II} \end{array}$$

re R, R^{I} and R^{II} are three different acid radicals. An example monly occurring mixed glycerides is one of the constituents er fat which on hydrolysis yields three fatty acids, butyric, ic and oleic, and has the structural formula—

$$\begin{array}{l} CH_2O.CO.C_3H_7 \\ | \\ CHO.CO.C_{15}H_{31} \\ | \\ CH_2O.CO.C_{17}H_{33} \end{array}$$

re several mixed glycerides constitute the fat, quite a large r of different fatty acids appear on hydrolysis.

hydrolysis of the many fats and oils derived from plant imals has yielded a considerable number of fatty acids, some ed (as lauric, palmitic, stearic, etc.), and others unsaturated ne or more double bonds (as oleic, linoleic, linoleinic, etc.).

common animal fats, suet, tallow and lard, yield chiefly ic, stearic and oleic acids; butter fat contains these and also others (lauric, capric, caproic and butyric). Plant oils derived from their seeds or fruit pulp (olive), taken as a whole e a very wide range of acids, both saturated and unsaturated. ean oil contains 15 per cent. mixed palmitic and stearic acids, cent. oleic acid and 20 per cent. lower fatty acids as lauric $C_{11}H_{23}COOH$, myristic acid, $C_{13}H_{27}COOH$, etc. Coconut oil is 85 per cent. of these lower fatty acids and linseed oil 93 per Fats of aquatic origin, both plant and animal, contain ly high proportions (75 to 80 per cent.) of a variety of rated acids. The component fatty acids of the higher land s are almost always oleic, palmitic and stearic acids. Tallow s 40 per cent. mixed palmitic and stearic acid and 6 per cent. od. Land plants show most consistently palmitic and oleic nd in addition linoleic acid. In any seed fat these three he bulk of the component acids. Linoleic acid is prominent

in many seed fats of the conifers and of the larger trees and s
Saturated acids of lower molecular weight such as lauric and my
acids are characteristic of tropical families, as the palm.

SATURATED FATS AND ACIDS.

Ester.	Occurrence.	Acid.	
Butyrin ...	Butter fat	Butyric	C_3H_7CO
Caproin ...	Coconut oil	Caproic	$C_5H_{11}C$
	Butter fat		
Caprylin ...	Coconut oil	Caprylic	$C_7H_{15}C$
	Butter fat		
Caprin ...	Goats' milk fat	Capric	$C_9H_{19}C$
	Cod Liver oil		
Laurin ...	Laurel oil	Lauric	$C_{11}H_{23}$
	Coconut oil		
Myristin ...	Coconut oil	Myristic	$C_{13}H_{27}$
	Butter fat		
Palmitin ...	Palm oil	Palmitic	$C_{15}H_{31}$
	Lard		
	Butter Fat		
Stearin ...	Tallow	Stearic	$C_{17}H_{35}$
	Lard		
	Butter fat		
Arachdin ...	Pea-nut	Arachidic	$C_{19}H_{39}$

UNSATURATED FATS AND ACIDS.

Ester.	Occurrence.	Acid.	
Olein ...	Olive oil	Oleic	$C_{17}H_{33}$
	Cotton Seed oil		
	Lard,		
	Butter fat.		
Linolein ...	Linseed oil	Linoleic	$C_{17}H_{31}$
Linoleinin ...	Linseed oil	Linolainic	$C_{17}H_{29}$

Fats differ from oils most simply in being more or
solid at ordinary temperatures. Yet all oils yield
fats on sufficient cooling and it must be remembered
the contents of fat cells are fluid during life, the b
heat being usually well above the temperature of solidi
tion of the fats found in the cells. Oils differ from

r fats also chemically in being more generally the atives of unsaturated acids as oleic, linoleic, etc. harder fats with the higher melting point consist y of the glycerides of the saturated fatty acids, tic and stearic acids. Thus the melting point of tripalmitin is 63 C and that of pure tristearin is C. ; triolein does not solidify until –4°C.

formation of fats in the course of the metabolism of plants nimals is not yet fully understood. It would, however, that fats are produced from previous soluble carbohydrates process of reduction, effected either by the cell protoplasm y or at second hand by an enzyme secreted for the purpose. ntrary process whereby fat food reserve is quickly converted luble carbohydrates, as in the germination of sunflower seed he course of heavy exercise or hard work on a fat diet, is one dation. The change either way is one of energy content ; a fat being much higher than that of a carbohydrate ; 1 gram on combustion yields 9.3 calories, as against 4.1 calories from of carbohydrate. The reduction of a carbohydrate to fat in neans an increased storage of energy and the reverse oxidation to carbohydrate a liberation of energy over and above that may appear subsequently on the complete oxidation of the ydrate to carbon dioxide and water. The greater proportion energy in fat inheres in the acid radicals.

s and oils are insoluble in water, slightly soluble in ol but readily in ether, carbon tetrachloride, petrol enzine.

s being esters are neutral substances. When treated caustic alkalies or saponified they decompose with the tion of glycerol and the formation of a metallic salt acid radical—a soap, both soluble.

$$OOC.C_{17}H_{35})_3 + 3NaOH = C_3H_5(OH)_3 + 3NaOOCC_{17}H_{35}$$

Tristearin Glycerol Soap

neral oils, as paraffin, are non-saponifiable.

en fats are subjected under suitable conditions of erature and pressure, as of superheated steam, they drolysed, their molecules taking up the elements of and splitting into glycerol and free fatty acids. hot liquid fats are run together with sulphuric acid, rol and free acids are liberated. Hydrolysis may be ed at ordinary temperatures by the action of a fat- ng enzyme, lipase, extracted from castor oil seed and ound in the pancreatic juice.

$C_3H_5(OOCC_{17}H_{35})_3 + 3H_2O = C_3H_5(OH)_3 + 3HOOCC_{17}$
Tristearin Glycerol Stearic

Natural fats all yield after hydrolysis a small am
of non-saponifiable residue in which vitamins may o

The fatty acids and fats fall into two groups acco
to whether they are saturated or unsaturated.
unsaturated acids and fats have in their structure
two or more "ethenoid" double bonds for each
acid molecule. They are characterised by the pro
of taking up hydrogen under certain conditions wit
formation of saturated or less un-saturated compo
This property is now made use of industrially in
hydrogenation or the "hardening" of unsaturated
as cotton seed, pea-nut and soya bean oils so that
are made available either as foodstuffs in margarine
artificial lard, or as materials for the manufacture of
and candles.

The ethenoid bond will also take up halogens—chlorine, bro
or iodine—two atoms of each for every double bond. Olei
$C_{17}H_{33}COOH$, is typical of the acids with one ethenoid bon
takes up two atoms of bromine or iodine per molecule; linolei
with two bonds takes up four halogen atoms per molecule
linoleinic acid with three bonds takes up six halogen atom
molecule. The triglycerides containing three acid radical
molecule will of course take up three times the quota fo
corresponding acid. The quantity of bromine, or more us
iodine, absorbed per 100 grams of the unsaturated acid is a me
of the degree of unsaturation of the acid. The iodine val
oleic acid is 90.07, that of linoleic acid 181.42 and that of lino
acid is 274.1. The iodine values of certain common fats an
are as follows: linseed oil, 173-201; cotton seed oil, 108
pea-nut oil, 83-100; olive oil, 79-88; lard, 50-70; beef ta
38-46; and butter-fat, 26-38.

LIPOIDS.

The term "Lipoid," or fat ally is applied to substances fou
cell protoplasm (especially in that of nerve cells) which like fa
soluble in ether and alcohol and are consequently found mixed
fats when tissues are extracted with these solvents. Lipoid
grouped with fats under the general designation of "lipids."

Lipoids form several distinct groups, such as:—

i. Sterols.

These are free from nitrogen and phosphorus and include cholest
calciferol, vitamin D, carotene, and many hormones. The
contain the tricyclic phenathrene ring.

actosides.

se are free from phosphorus and contain nitrogen; when ysed they yield, among other substances, the hexose sugar, ose.

osphatides.

se contain phosphorus and organic bases with nitrogen. The nown is lecithin. They occur in the liver, kidney, pancreas, ain.

lesterol gets its name from the fact that it is a constituent of orming gall stones when in excess. It is abundant in the and is found in blood and tissues generally. It plays an ant part in the transport and metabolism of fat.

a monohydric unsaturated alcohol of the terpene series with pirical formula $C_{27}H_{46}OH$, and combines, as in lanoline, leic, palmitic and stearic acids. Its isomer, phyto sterol, is in vegetable fats.

osterol, $C_{28}H_{44}O$, usually accompanies cholesterol in plant imal fats. Its chief significance lies in the fact that exposed rt light waves (violet and ultra-violet) it ultimately yields rol, or vitamin D_2 (see p. 112).

otene, $C_{40}H_{50}$, is found in relative abundance in green plants ociation with chlorophyll, and sparsely in animal fats. It is rtible in the body into vitamin A (see p. 97).

thin, yields on hydrolysis four substances; one molecule f glycerol and phosphoric acid; two molecules of a fatty acid, which is normally oleyl, and one molecule of the nitrogen ning base, choline—all linked through glycerol as indicated.

Glycerol — 1st fatty acid radicle R^{I}.
2nd fatty acid radicle R^{II}.
phosphoric acid radicle—choline radicle.

thin is an important constituent of red blood corpuscles.

EXPERIMENTS ON FATS.

Physical Properties.

Experiment 1.

To prepare crystals of fat.

some suet into small pieces and warm on a water-bath until nent. Strain through muslin. Dissolve a little of the sample er in a test tube. Filter through a folded filter-paper without on to a clean watch glass. Allow to stand away from flames crystals are deposited. Examine the crystals under the scope and make sketches of their shape.

Experiment 2.

To determine the melting point, vaporisation point and flash of a natural fat.

Melting Point.

Since natural fats are mixtures of several glycerides, all m at different temperatures, the melting point occurs over a ra temperature and not sharply at one single temperature as a single substance. For ordinary purposes the capillary method gives the best results. Scrape a piece of capillary about 6 cms. long 0.5 to 1 mm. bore and wall 0.1 mm. thick. h over the surface of the fat to introduce thin curls of fat up on of the tube. Leave the tube open at both ends and attach means of a narrow rubber band to a thermometer with the close proximity to the bulb. Suspend the thermometer in a b of cold water. Raise the temperature of the water very grad by means of a small flame and at the same time stir the wat disperse the heat uniformly. Watch the particles of fat care the whole time and note the temperature at which they beg lose their shape and run together. This temperature is know "Incipient Fusion." Continue to heat until the fat becom clear liquid. This gives the temperature of complete fusion. determination should be done in duplicate and an average obtained. If any difficulty is experienced in introducing soli into the capillary tube the fat may be melted and a little drawn up the capillary tube as a pipette. In this case, how an interval of at least three days must elapse before the me point is determined in order to allow the fat to become stable.

To determine the solidification point take a tube 1½ inches and 6 inches long, fitted with a thermometer and stirrer, half with molten fat and suspend it in a wide-mouthed glass vess exclude draughts. Allow the fat to cool with constant stirring watch the thermometer carefully. The temperature will slowly until solidification takes place and then rises sharply. maximum temperature recorded during this rise is taken as solid tion point. The fusion and solidification points of butter, marga lard, mutton fat and beef fat can be determined by these meth

Vaporisation Point.

This is the temperature at which visible vapours are given from the fat or oil. Place about 20 grams of the fat, e.g., ta in a porcelain crucible resting on a sand-bath and suspend a range thermometer so that the bulb is covered by the fat melted. Now apply heat from the burner under the sand- until the fat begins to smoke. At this point remove the flame watch the crucible until the vapours just cease to be given off then read the temperature. Tallow ceases to vapourise bet 125°-160°C. (260°-320°F.). Mineral oils vapourise between 80 C. (180°-220°F.). Great care must be taken in experiments mineral oils.

Point.

his is the temperature at which a substance vapourises and es on exposure to a naked light. Draw out a glass tube to a point and connect by a length of rubber tubing to a gas jet. t the gas at the end of the fine glass tube and turn it down so the flame is as small as possible. Now slowly raise the tempera- of the fat, e.g., tallow, and pass the little gas flame just over surface of the fat at short intervals until the vapours are seen entarily to ignite with a small blue flash. Good quality tallow ld give a first flash at about 260°C. (500°F.). Mineral oils at a much lower temperature ; hence the need for special care.

Experiment 3.

To investigate the solubility of fats in different solvents.

troduce pieces of fat about the size of a pea into a series of -tubes. Half fill the test-tubes with each of the following ents (*a*) water, (*b*) alcohol, (*c*) ether, (*d*) benzene, (*e*) chloroform, arbon tetrachloride. Shake up each test-tube well and test the bility when cold and hot. (N.B.—Some of the solvents used nflammable.) If you are not sure whether any fat has dissolved ot, filter and test the filtrate for fat by noting whether or not a sy mark is left in the container after evaporation.

Experiment 4.

o compare the emulsifying powers of various aqueous solutions.

ace in a series of test-tubes 10 ccs. of each of the following ents (*a*) water, (*b*) 2 per cent. caustic soda solution, (*c*) 2 per cent um carbonate solution, (*d*) 2 per cent. sodium bicarbonate tion, (*e*) 2 per cent. borax solution, (*f*) 2 per cent. acetic acid tion. Add 1 cc. of olive oil to each and shake each thoroughly as nearly as possible the same length of time. Note in which s an emulsion is formed and how permanent it is. Examine a of each emulsion under the microscope and conclude as to ther there is any connection between the size of the droplets the permanence of the emulsion. What inferences can be vn from these experiments as to methods of removing grease, from clothing.

Experiment 5.

To investigate the action of dry heat on fat.

Place a suitable quantity of fat in a small distilling flask nected with a condenser and receiver. Fit the distilling flask a high range thermometer dipping into the fat. Heat the fat and whether or not the fat distills unchanged, at what temperature distillate is formed and what is its appearance, smell and tion to litmus.

his experiment should emphasise the importance of not over- ing fatty foods

Experiment 6.

Qualitative test to distinguish between a saturated and unsaturate

Dissolve separately 1 cc. of olive oil and melted lard and liver oil in equal volumes of ether, e.g., 10 ccs. Add 1 per iodine solution in alcohol drop by drop to each solution. the number of drops necessary to produce a permanent yellow co Conclude as to the degree of unsaturation of the two fats. also Iodine Value—Experiment 12.)

Experiment 7.

To determine whether or not fat is present in a food.

If the food contains a little moisture place a little of it on t paper and warm gently on a hot surface. In the presence of a translucent grease spot will be produced. If the food con much moisture it must be previously dried. Warm a little of a test-tube with ether by placing in hot water. Pour some of ether extract on a filter paper. Allow the ether to evaporate a from flames. As before, a translucent grease stain will indicate presence of fat.

Experiment 8.

To determine the amount of fat in a food.

Dry a weighed amount of the food by heating in a weig evaporating basin in a water oven to constant weight. Add et to extract the fat. Pour the ether extract into a weighed evapo ing basin and remove the ether by evaporation on a water b away from flames. Weigh the residual fat and calculate percentage present in the food taken. A more accurate determi tion of the amount of fat present can be made by means of Soxhlet extraction apparatus if one is available. For detail this method see page 76.

Chemical Properties.

Experiment 9.

To investigate the saponification of fats.

Make an alcoholic soap solution. To a portion add dil sulphuric or hydrochloric acid. Explain the action. To a sec portion apply the following test for glycerols.

(a) Dunstan's test for glycerol (free).

To 5 ccs. of 5 per cent. borax solution add sufficient phe phthalein solution to give a well marked colour. Add a new solution of glycerol drop by drop until the pink colour just appears. Boil and note the reappearance of the pink colour.

(b) Acrolein test for glycerol (combined or free).

Heat a little glycerol in a dry test-tube with an equal bulk of a potassium sulphate which acts as a dehydrating agent. Note

ation of acrolein vapour with the characteristic smell of burnt

$CH_2OH.CH.OH\ CH_2OH - CH_2 : CH.CHO + 2H_2O.$

Experiment 10*.

To determine the Saponification Value of a fat or oil.

e saponification value of a fat or oil is the number of milli-mes of potassium hydroxide required to saponify completely am of the fat or oil.

eigh out accurately about 2 grms of the fat into a round-omed flask of 250 ccs. capacity and add 25 ccs. of N/2 alcoholic tic potash solution. An alcoholic solution is necessary to re complete saponification. It is prepared by weighing out t 8 gms of pure stick potassium hydroxide, dissolving it in the lest possible quantity of water and making up to 250 ccs. in a uated flask with 95 per cent. alcohol. Standardise this solution nst N/2 acid.

fter the addition of the alcoholic potassium hydroxide solution he flask with a glass tube about 30 inches long to act as an air lenser. Heat the flask on a water bath with an occasional e for 30 minutes or until saponification is complete. Remove air condenser, and add to the contents of the flask 10 drops of ol phthalein solution made by dissolving 1 gram of phenol halein in 100 ccs. of alcohol and stored in a dropping bottle. ate the warm contents of the flask with N/2 hydrochloric acid l the pink colour of the phenol phthalein just disappears. y out a duplicate determination and a blank experiment using cs. of the alcoholic potassium hydroxide solution without any Calculate the saponification value as follows :—

W = Weight of fat taken.

X = Number of ccs. of N/2 acid required by blank experiment.

Y = Number of ccs. of N/2 acid required to neutralise excess alcoholic potassium hydroxide solution after saponification.

∴X—Y = Number of ccs. of N/2 acid equivalent to the KOH solution used up in saponification.

But (X—Y) ccs. N/2 acid = (X—Y) ccs. N/2 KOH.

$$= \frac{(X-Y) \times 28.05}{1000} \text{ gms. KOH.}$$

∴W. grms. fat require $\frac{(X-Y) \times 28.05}{1000}$ gms. of KOH for saponification.

∴1 gm. of fat requires $\frac{(X-Y) \times 28.05}{1100} \times 1000$ milligrams of KOH for saponification.

∴Saponification Value = $(X-Y) \times 28.05$.

Experiment 11.*

To determine the Acid Value of a Fat or Oil.

The acid value of a fat or oil is a measurement of the amou free fatty acid present in the fat or oil.

It is expressed as the number of milligrammes of potas hydroxide required to neutralise the free fatty acid in 1 gra the fat or oil or alternatively as the percentage of oleic acid pr in the fat.

Weigh out accurately 5 gms. of the fat or oil into a clean conical flask. Warm the flask gently to melt the fat and add 50 ccs. of an alcohol-ether mixture containing 3 volu 95 per cent. alcohol to 1 volume ether. Shake to dissolve the fatty acids. Add a few drops of phenol phthalein solution titrate the contents of the flask with N/10 caustic soda solu until a permanent faint pink colour is produced. The flask sh be well shaken after each addition of alkali and the contents k warm. The acid value is calculated as follows :—

X = Number of ccs. of N/10 NaOH required to neutralise fatty acids.

W = Weight of fat taken.

$$\text{Acid value} = \frac{X \times 5{\cdot}61}{W}$$

$$\text{Percentage of Oleic acid} = \frac{X \times 2{\cdot}82}{W}$$

Experiment 12.*

To determine the Iodine Value of a Fat or Oil.

The iodine value of a fat or oil is a measure of the degree unsaturation of the fatty acids in the fat or oil. It is expressed the number of grams of iodine absorbed by 100 gms. of the fat or

Wijs method gives the best results and the following reage are required :—(*a*) *carbon tetrachloride* which has been redistil and dried over fused calcium chloride (*b*) *soluble starch soluti* prepared by adding 100 ccs. of boiling distilled water to 1 gm. soluble starch previously made into a cream with a little cold wat (c) *potassium iodide* solution prepared by dissolving 10 gms. potassium iodide in 100 ccs. of distilled water ; (*d*) *N/10 sodi thiosulphate solution* prepared by dissolving 6·25 gms. of sodi thiosulphate in 250 ccs. of water and standardising this soluti against N/10 potassium dichromate solution (4·903 gms. litr This is done by placing 25 ccs. of the N/10 $K_2Cr_2O_7$ solution in

l flask with 10 ccs. of a 10 per cent. potassium iodide solution
5 ccs. of concentrated hydrochloric acid. The free iodine
ted is titrated against the sodium thiosulphate solution using
e starch solution as indicator. The sodium thiosulphate can
be made exactly deci-normal by the addition of the necessary
nt of water or a factor can be employed. 1 cc. of the N/10
n thiosulphate solution will be equivalent to 0·0127 gm. of
e. (*c*) Wijs *solution of iodine monochloride.* A 10 gm. tube of
e trichloride is carefully opened and its contents shaken into
e of glacial acetic acid. The iodine trichloride is dissolved by
ng and gentle warming on a water-bath. 5 ccs. of the solution
luted with 30 ccs. of water and 5 ccs. of the previously prepared
sium iodide solution added. The mixture is then titrated
the N/10 sodium thiosulphate solution using the soluble starch
on as indicator. The amount of N/10 sodium thiosulphate is
ly between 8 and 9 ccs. About 12 gms. of powdered iodine
issolved by warming on the water-bath in about 300 ccs. of
odine trichloride solution. This solution is then added to the
inder of the iodine trichloride solution until its darkening in
r indicates no further absorption of iodine. A further titration
N/10 sodium thiosulphate is carried out with 5 ccs. of the
ion and if half as much again (12—13·5 ccs.) are required the
e of the iodine trichloride has been converted into iodine
ochloride. A small excess of iodine is now added and the
ion filtered into a dry coloured bottle and stored in a dark place.

out 0·1 gm. of the fat is accurately weighed out into a clean
stoppered iodine bottle and then dissolved in 10 ccs. of carbon
chloride solution. When the fat has dissolved, exactly 10 ccs.
e Wijs solution is pipetted into the bottle and allowed to stand
e dark for an hour. 10 ccs. of the 10 per cent. potassium
e solution are now added together with 60 ccs. of distilled water.
contents of the flask are now titrated with the N/10 sodium
ulphate solution using soluble starch solution as indicator
the contents of the flask turn a pale straw colour.

rry out duplicate determinations and a blank experiment using
e reagents except the fat. The result is calculated as follows :—

W = Weight of fat taken.

X = Number of ccs. of N/10 $Na_2S_2O_3$ used in the blank expt.

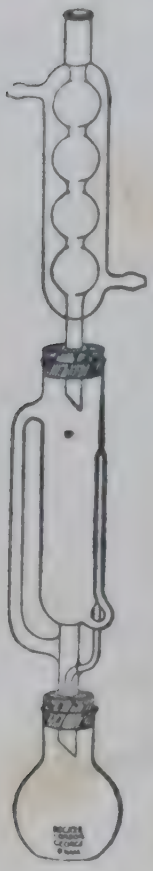
Y = Number of ccs. of N/10 $Na_2S_2O_3$ needed in the experiment.

The (X—Y) ccs. = number of ccs. of N/10 iodine used up by W gms. of the fat.

$$\therefore \text{Iodine Value} = \frac{(X-Y) \times 0{\cdot}0127 \times 100}{W}$$

obtain reliable results the weight of fat taken should be chosen
at not more than 30 per cent. of the available iodine in the Wijs
ion is absorbed.

Experiment 13.*



To determine the percentage of Fat in Foo the Soxhlet Method.

Weigh out 5 grams of the food into a Soxhlet thimble. Suspend the thimble beaker and dry it to constant weight in a s oven. Place it in the Soxhlet extraction attached to a previously weighed flask contai sufficient ether to fill the thimble and hal the flask. Now attach the reflux condense the extraction tube. Heat the flask by m of a water-bath or electric hotplate so a keep the ether gently boiling. The ether vap passes up the side-tube of the extractor to reflux condenser where it is condensed and back on to the food in the thimble. When thimble is practically full, the ether is retur to the flask by an automatic syphoning dev carrying with it some of the fat from the f In this way, although a comparatively sm quantity of ether is used, the food is being stantly extracted with fresh fat-free solvent.

When extraction is considered to be compl dismantle the apparatus and evaporate off ether on a water-bath away from flames. Fina weigh the flask and its fat content. The incre in the weight of the flask will give the weight fat extracted from a known weight of the f and consequently the percentage can be culated.

FIG. 6. Soxhlet Apparatus for determination of fat.

CHAPTER VII.

PROTEINS AND AMINO-ACIDS.

ins. Proteins are the most highly complex chemical substances known. Like the carbohydrates and hey are essential components of all organisms—plant animal; the living substance itself, protoplasm, is a plex of many proteins. They contain as their tial elements, carbon, hydrogen, oxygen and nitrogen. contain in addition sulphur, and a few of the highest associated with the nuclei of cells, phosphorus also. ne average, analysis of a protein yields the following ortions of the elements; carbon 51-55 per cent. ogen 6-7.7 per cent., oxygen 20-24 per cent., nitrogen per cent., sulphur 0·3-2·3 per cent., and phosphorus, present, 0·4-0·8 per cent. In the majority of pro- the percentage of nitrogen is round about 16 per ; hence the factor 6·25 is commonly used for erting the amount of nitrogen obtained by Kjeldahl's od into amount of protein; in the case of milk eins the factor is 6·38 and for vegetable proteins

size of the protein molecule as indicated by any sort of rement would appear to be very considerable. That of egg in, whose empirical formula is $C_{146}H_{226}N_{44}SO_{50}$, is calculated out 34,500 and many soluble proteins show multiples of this . Even the lowest value obtained from the formula of oxy- globin, $C_{655}H_{1181}O_{210}N_{201}S_2Fe$, is about 16,700 and the value is almost certainly a multiple of this—about 68,000; -globulin is of the order of 104,000 and edestin of 208,000. ed to the immense size of their molecules is the fact that all most characteristic physical properties are those typical of ds.

very large number of separate proteins have been nguished in the tissues of animals and plants. e were formerly most conveniently classified according ertain simple properties, such as their behaviour to , whether they were coagulated or not, and as to solubility in various solvents such as water, alcohol salt solutions of different concentrations. The

albumins (egg, milk- and blood-albumin) coagulate heat and are soluble in water : globulins (serum-glob coagulate with heat, and are insoluble in water soluble in salt solution : the phospho-proteins (ca being acidic dissolve in alkalies ; they do not coag when warmed.

Proteins are now usually grouped according to the compl of the molecule as simple and as conjugated proteins, to whic added the derived proteins, or products of the action of he partial hydrolysis on proteins. The commonest proteins ma hus classified :—

I.—Simple Proteins.

(i) Albumins—

Egg, blood, milk and plant albumins—typical prot
Soluble in water and coagulated by heat.

(ii) Globulins—

Egg- and serum-globulin, fibrinogen (blood) p
myosinogen (muscle) edestin (hemp-seed).
Insoluble in water ; soluble in solutions of N
and $(NH_4)_2SO_4$.

(iii) Glutelins—

Glutenin (wheat gluten).
Soluble in dilute alkalies and acids ; insoluble in w
and salt solution.

(iv) Prolamins—

Gliadin (wheat gluten), zein (maize), hordein (barley
Soluble in 70-80 per cent. alcohol ; insoluble in w
and salt solutions.

(v) Sclero-proteins—

Chondrin (cartilage), collagen, gelatin, and ela
(connective tissue), keratin (hair, horn).

(vi) Histones—

Globin (hæmoglobin of blood).
Basic and soluble in water and dilute acids ; precipita
by ammonia.
Composed of mono- and diamino-acids.

(vii) Protamines—

Salmine (fish roes).
Basic and soluble in water ; simplest of proteins.
Rich in arginine.

(viii) Phospho-proteins—

Caseinogen and Casein (milk), vitellin (egg-yol
Phosphorus combined within the protein molecule
Of special value to young and embryonic animals.

II—Conjugated Proteins.

tein molecule united with a second—the prosthetic group.

) Chromo-proteins—

Hæmoglobin.

Prosthetic group, contains a metal (iron in hæmoglobin and copper in hæmocyanin).

) Gluco-proteins—

Mucin and mucoids (connective tissue—white of egg).

Consist of protein and a carbohydrate group.

) Nucleo-proteins—

Globulin and histone of nucleo-protein and protoplasm.

Consist of protein and much nucleic acid, which yields ultimately phosphoric acid, a carbohydrate, purine (guanine, adenine) and pyrimidine (cystosine) bases.

III—Derived Proteins.

n protein material is hydrolysed, that is, has the elements of added to its molecules either by action of an acid or super- steam or of proteolytic enzymes (pepsin, trypsin, erepsin), it progressively into a succession of simpler derived proteins ields ultimately its constituent amino-acids. The various are as follows :—

) Meta-proteins.

) Proteoses.

Peptones.

) Polypeptides—compounds of two or more amino-acids.

Amino-acids.

o-Acids. Although many hundreds of different proteins have been obtained from a variety of sources, they yield altogether reduced, as it were, "to produce" only some y fundamental units—the amino-acids. Some ns consist of few amino-acids, others of many. n amino-acids are generally distributed among the ns ; in some cases in large proportions, in others in proportions, while a few are restricted to a limited of proteins. The nature of a particular protein lered as a foodstuff depends essentially upon its onent amino-acids and upon the proportions in which occur within its molecule. Gliadin of wheat gives per cent. of the amino-acid glutamin and only per cent. of arginine ; while salmine from the milt

By courtesy of U.S. Bureau of Home Econom

FIG. 7. FIG. 8. FIG. 9.

PROTEINS FOR BUILDING TISSUES.

Rats from the same litter, 11 weeks old.

FIG. 7. This rat had good protein, but not enough. It we 70 grams.

FIG. 8. This rat had enough protein, but of a poor kind weighed only 65 grams.

FIG. 9. This rat had good protein and plenty of it. It normally and weighed 193 grams.

mon yields no glutamin but 89·20 per cent. of
ne. The significance of a particular amino-acid
represented in the food of animals lies in the fact
he higher proteins needed for the replacement and
ng of the protoplasm of nerve and gland cells con-
mall but indispensable amounts of tryptophane and
, unless these are supplied in the food, growth and
l life itself cannot be maintained (see also page 161).

amino-acids are in the main derivatives of " straight chain "
cids in which one or more of the hydrogen atoms have been
d by an amino ($-NH_2$) group. The simplest amino-acid,
, is a derivative of acetic acid ; thus acetic acid is CH_3COOH
lycine, or to give its other name, amino-acetic acid, is
H_2COOH. Alanine, another simple amino-acid is amino-
nic acid, $CH_3CH(NH_2)COOH$. The molecules of amino-acids
tain both the positive or amino group, NH_2, and the negative
oxyl group, COOH and in consequence they can function as
asic and acidic substances (amphoterics) and are capable of
ing with one another with the elimination of water to form
s orders of a great variety of more complex derivatives.
one molecule of glycine may link up with another to form
lycine.

$$H_2N.CH.CO(OH\ H_2)N.CH.COOH$$
$$\quad\ |\qquad\qquad\ |$$
$$\quad H\qquad\qquad H$$
$$> H_2N.CH.CO{-}HN\ \ CH.COOH + H_2O$$
$$\quad\ |\qquad\qquad\ |$$
$$\quad H\qquad\qquad H$$

glycyl glycine has still both NH_2 and COOH groups and can
re link up with a third molecule of glycine or with another
-acid altogether to form a still more complicated network.
most accomplished so far in the laboratory in the building up
simple amino-acids more complex compounds has been to
p three molecules of leucine with 15 of glycine to give a
nce with a molecular weight of 1212. Such a synthetic
ptide is but a little on the way to the synthesis of a simple
with the minimum molecular weight of, say, 16,000.

ording to their chemical affinities and structures the amino-
may be grouped conveniently as follows :—

(1) **Mono-basic—mono-amino acids.**

(i.e., with one NH_2 and one COOH group).

Glycine (NH_2CH_2COOH) alanine ($CH_3CH.NH_2.COOH$).

Valine (amino-valeric acid), leucine (amino-caproic acid) iso-leucine, caprine.

(ii) **Di-basic—mono-amino acids.**
(i.e. with one NH_2 and two COOH groups).
Aspartic acid ($CH.NH_2COOH\ CH_2COOH$).
Glutamic acid ($CH.NH_2COOH\ CH_2CH_2COOH$).
Asparagine.

(iii) **Hydroxy and Thio-amino acids.**
The former with OH groups and the latter with sul
Serine, cystine, etc.

(iv) **Di-amino acids.**
(i.e., with two NH_2 groups).
Ornithine, lysine, arginine.

(v) **Hetero-cyclic amino-acids.**
(With ring and carbon and nitrogen nuclei).
Proline, histidine, tryptophane.

(vi) **Aromatic amino-acids.**
(With benzene ring).
Tyrosine ($HO.C_6H_4CH_2CH.NH_2COOH$).

EXPERIMENTS ON PROTEINS.

Experiment 1.

Nitrogen Tests for Proteins.

(*a*) Heat a small quantity of the substance, e.g., gelatin, i ignition tube. Note the fumes smelling of burnt feathers or h hair. In some cases, ammonia fumes can be recognised.

(*b*) Heat a small quantity of the protein substance, e.g., ch with excess soda-lime in an ignition tube. Test the fumes ev for ammonia by their smell and their action on moist red litm

(*c*) Place a small piece of metallic sodium in a small test-tub add the substance to be tested, e.g., cheese. Heat the tube g a first until the reaction is complete and then heat strongly the test-tube becomes red hot. Allow it to cool slightly and drop it into about 10 ccs. of water in a small beaker of water. glass breaks, any undecomposed sodium decomposes with a the cyanide formed dissolves in the water and small pieces of c float about in the liquid. Filter into a second test-tube. filtrate should be an alkaline solution of sodium cyanide. A the filtrate a few drops of ferrous sulphate solution and a dr ferric chloride solution. Boil for a short time, cool under th and then acidify with dilute hydrochloric acid. The formation precipitate of Prussian blue (ferric ferrocyanide) indicates the pre of nitrogen.

Experiment 2.

Colour Tests for Proteins.

out the following tests on the following solutions :—

Simple protein—peptone solution (2 per cent.).
Sclero protein—gelatin solution (1 per cent.).
Complex protein—egg white solution (10 per cent.). blood serum solution.

th-Protein Reaction.

bout 5 ccs. of the protein solution add an equal volume of rated nitric acid and heat until precipitate first formed ssolved. Cool *thoroughly* and then add ammonia slowly. nge colouration indicates the presence of protein containing enyl (C_6H_5) group in the molecule, e.g., tyrosine, phenyl- and tryptophane (egg albumin).

ret Reaction.

little 10 per cent. caustic soda solution in a test-tube add copper sulphate solution drop by drop until the precipitate rmed has re-dissolved and only a faint blue colour remains. dd the protein solution and either warm gently in a water r leave to stand. A colour change which may vary from o pink indicates the presence of protein. Complex proteins violet colouration. Simpler proteins of the peptone type pink colouration. Reaction depends upon the presence of $CO.NH_2$ groups joined directly or by way of an intermediate

$$\text{e.g. biuret} \quad \begin{matrix} CO.NH_2 \\ >NH \\ CO.NH_2 \end{matrix}$$

on's Reaction.

he protein solution in a test-tube add an equal volume of s reagent. The formation of a white precipitate which turns ed on heating indicates the presence of proteins containing droxy-phenyl group C_6H_4OH, e.g., tyrosine group (example, umin). This reaction does not work in the presence of much chlride.

oxylic Reaction (Adamkiewiez Reaction).

ne protein solution in a test-tube add an equal volume of the lic reagent (reduced oxalic acid solution). Shake together en pour concentrated sulphuric acid carefully down the side ilted test-tube so that it sinks to the bottom as a separate A purple ring formed at the junction of the two layers s the presence of proteins (e.g., egg albumin) containing the hane group.

Sulpho-salicylic acid Test.

eful reagent for testing small quantities of proteins in urine lbuminaria) is sulpho-salicylic acid. Try out with various ing dilutions in water of 0·5 per cent. albumin solution.

Experiment 3.

To show the colloidal nature of proteins.

Place in a dialyser some of the protein solution, e.g., egg w and add a little chloroform to prevent decomposition. After se hours test the liquid outside the dialyser for protein by the B reaction. No colouration should be produced showing that pr are colloids and because of the largeness and complexity of molecules are unable to diffuse through animal membranes they are broken down into amino-acids.

Experiment 4.

To investigate the precipitation of complex proteins from sol

Prepare a 10 per cent. egg white solution and test the action it of the following reagents.

(*a*) Strong tea or tannic acid solution (10 per cent. solution
(*b*) Picric acid solution.
(*c*) Dilute mineral acid, e.g., nitric acid.
(*d*) Mercuric chloride solution.
(*e*) Copper sulphate solution.
(*f*) Ferric chloride solution.
(*g*) Lead acetate solution.

If no reaction is given try the addition of a drop of acid or to the reagent.

From your tests draw conclusions as to :—

(i) The use of tea brewed for a long time with eggs, me cheese.
(ii) The use of milk with tea.
(iii) The use of vinegar with meats or fish.
(iv) The use of egg-white in lead poisoning.
(v) The possible effects of any of the above reagents o delicate lining of the digestive tract.
(vi) The use of tannic and picric acid for burns.

Experiment 5.

To investigate the coagulation of complex protein by heat and al
(albumin and globulin).

(*a*) *Heat.*

Introduce a little egg-white into a test-tube and place in a b of water with a thermometer. Heat gently and note the temper at which coagulation begins. Remove a little of the coag Continue to heat the remainder and remove samples at va higher temperatures. Compare the taste and texture of the va samples of coagulum and draw conclusions as to the cooking o and other protein foods.

ins coagulate most readily with heat after being denaturised; converted into metaproteins by partial hydrolysis with acid n. Boil 5 ccs. of blood serum solution; there is opalescence real coagulation. Cool, and add drop by drop 1 per cent. cid. A precipitate of metaprotein forms, but dissolves with of the acid. Repeat taking 5 ccs. serum solution, add a per cent. acetic acid and boil. Coagulation occurring, cool d two or three drops of strong nitric acid or acetic acid. no solution of the coagulate, as there was of the precipitate.

ohol.

e a little egg-white in a test-tube and add concentrated (methylated spirit). Filter the precipitate from the alcohol d out whether it will re-dissolve in water. Draw conclusions he effect of alcoholic beverages upon protein food materials.

Experiment 6.

estigate the action of concentrated acid on complex protein

gg-white in a test-tube add an equal volume of concentrated hloric acid. An acid coagulum will be formed. Heat the e gently until the coagulum dissolves. Place in a water-bath ontinue the heating for several hours. Apply the biuret n after first neutralising the solution.

ill be found that the acid hydrolyses the complex protein to a protein and then to amino-acids.

Experiment 7.

estigate the action of concentrated alkali on complex protein

gg-white in a test-tube add an equal volume of concentrated soda solution. Note the effect while cold and then heat. nd test the vapour by smell and moist red litmus. Test a n of the liquid for sulphide and carry out the biuret test on a portion.

pare the effect of concentrated alkali upon complex protein. hat of concentrated acid.

Experiment 8.*

To separate a mixture of proteins.

To a solution of egg-white in water in a test-tube add solid nium sulphate and shake vigorously. When the solution is ted with ammonium sulphate, filter and test the filtrate for n by the biuret reaction.

To a solution of egg-white in water in a test-tube add an volume of saturated ammonium sulphate solution. Filter and e filtrate for protein by the biuret reaction.

epeat (*a*) and (*b*) with magnesium sulphate or sodium chloride.

g blood serum, "full saturation" with ammonium sulphate

precipitates all proteins with the exception of peptones. "
saturation" with ammonium sulphate precipitates globulin
phospho-proteins, the albumins remaining unprecipitated. S
tion with magnesium sulphate or sodium chloride prec
globulins and phospho-proteins.

Hence in Experiment 8 (*a*) the biuret reaction should g
pink colouration due to peptones. Experiments (*b*) and (*c*)
give a violet colouration due to complex proteins.

Experiment 9.*

To determine the percentage of protein in a food (Kjeldahl Pro

The food material is boiled with concentrated sulphuric
which oxidises the organic matter and the nitrogen prese
converted into ammonium sulphate. Excess caustic soda i
added and the mixture distilled. The nitrogen is expell
ammonia which is absorbed in a known volume of standard
The excess of standard acid is determined by titration with sta
alkali. The amount of nitrogen can then be estimated and
when multiplied by the proper factor, gives the amount of prot

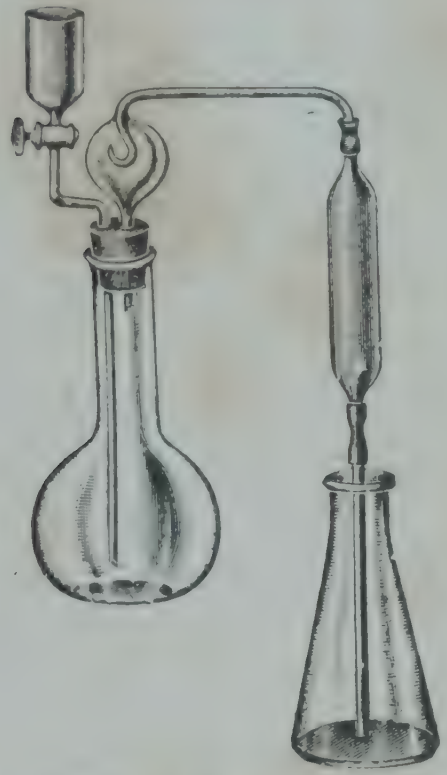
Weigh out accurately between 1 and 5 grams of the food i
round-bottomed Jena flask of 200-300 ccs. capacity (usually ter
Kjeldahl flask). Add 20 ccs. of concentrated sulphuric acid,
0·5 grams of copper sulphate which assists oxidation, and
5 grams of powdered potassium sulphate to raise the boiling
Place the flask in a fume-cupboard in a sloping position and
gently until the contents of the flask are either pale colour
clear.

Cool the flask carefully and when quite cold dilute the con
of the flask with about 70 ccs. of water. Add this water car
and shake and cool after each addition.

Connect the flask to the distillation apparatus. This is fitted
a "spray bulb" to retain any alkali, which may spurt upwards
a dropping funnel.

The end of the condenser just dips below the surface of 5
of N/10 acid in a beaker which should preferably be on a mov
base so that as the beaker fills it can be lowered to keep the
the condenser just below the surface of the acid. This is nece
to prevent sucking back. Place in the flask a few pieces of b
earthenware or zinc dust to prevent bumping during boiling.
a few drops of litmus into the flask. Fill the dropping funnel
50 ccs. or more of 40 per cent. caustic soda solution. When
apparatus is all fitted together run in the caustic soda solution
the dropping funnel until the contents of the flask are str
alkaline. Close the tap and heat the flask to boiling so tha
ammonia is distilled off. To test when all the ammonia has
distilled off, allow a drop of the distillate to fall on red litmus p
When the operation is complete, remove the beaker and titra
contents against N/10 caustic soda using methyl orange as indi

to the amount of acid neutralised by the ammonia and weight of nitrogen in the food material. The average e of nitrogen in a protein is 15-16 per cent. Hence the protein can be obtained by multiplying by the factor



IG. 10. Kjeldahl's distillation apparatus for determination of combined nitrogen.

CHAPTER VIII.

VITAMINS.

General. Until the last 15 to 20 years it was gen accepted that for all purposes of health should consist essentially of the three principles, pro fats and carbohydrates—the first for the bui maintenance and repairing of tissue, the latter tw the supply of energy—and of less importance a amount of mixed mineral salts. Nowadays to thes added the " accessory food factors " or vitamins, less essential, though they occur in natural foods in minute quantities only. Without the vitamins, in several types, even though all other food principle provided in full amount and perfect balance, healt in the end life itself cannot be maintained. In therefore, of reckoning the adequacy of a dieta before, in terms only of calories and proteins—first and second class—account must be taken also o several vitamins, listed as A, B complex, C, D, E, each of which plays its particular role in maintainin health of the system, while its absence is attended by special forms of " deficiency disease."

Although it is only within quite recent years tha knowledge has been well established of the significan vitamins in food and of their specific nature and beha it is nevertheless true that for many centuries wha now known as deficiency diseases were in a uncertain fashion related to certain types of food. it was recognised as long ago as the time of Chaucer scurvy could be prevented or even cured by the ad to the diet of sailors and explorers, of fruits and vegetables. In 1735 Casali in a description of the di pellagra noted in detail the deficiencies in the diets sumed in every case by the inhabitants of the distri Spain where this disease was rife. In 1734 Bach demonstrated that scurvy was due to nothing more

abstinence from fresh vegetable food and greens, ould be cured by the addition of relatively very uantities of these to a faulty dietary. In 1747, Lind, a naval surgeon at Haslar, divided twelve patients into six groups, and to each group made a t dietetic addition. The pair receiving oranges ns, were quickly cured and scarcely less quickly ho had cider. He confirmed observations which n made at the beginning of the eighteenth century ied vegetables were useless in times of war against and adopted the view that " no moisture whatso- uld restore the natural juices of the plant lost by ation." He was also struck by the good effect of nilk in the treatment of scurvy, supposing it to be ly vegetable liquor, an emulsion prepared of the ucculent wholesome herbs." Lind recommended oncentrated lemon juice syrup should be served nout the Navy, but his suggestions were at first unheeded so that in 1780, at least 2,400 men of the l Fleet were affected by scurvy, and the mortality ed that from battle and wounds. In 1793 on the ion of Dr. Blane the naval authorities made trial Lind's suggestions as to the use of lemons. The lk " made a voyage of 19 weeks without touching rt ; every man on board was given $\frac{3}{4}$ oz. of juice with 2 oz. of brown sugar in addition to his ations, and on arrival at Madras there had not single case of scurvy. Young recommended as an tive for the use of the Navy the plan of taking to purposes of food, beans, peas, barley, etc., in a f germination. It was by realising that there was ing present in fresh vegetables and fruit, without normal health was impaired, that Captain Cook is d not to have had a single case of scurvy in the of his many voyages of discovery—a fact in remark- ntrast to the great losses among the crews of the reat explorers, Vasco da Gama, Prince Henry of al, Anson, etc. Nelson maintained an extra- ily good bill of health throughout his fleets when l in continuous blockade, by means of a diet in ruit and fresh vegetables were common items.

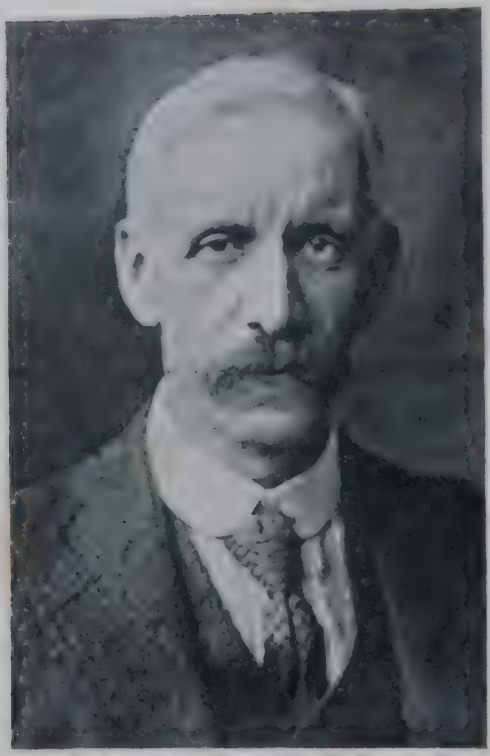
By the beginning of the 19th century the daily of one ounce of lemon juice on board ship was comp throughout the Navy, with the result that scurvy very rare. The lemon juice supplied to the Nav first made from lemons grown in Spain or other Me anean countries, but afterwards it was made from India limes, and scurvy again broke out. The for this was not discovered until recently, when shown that while the lemon is particularly rich anti-scorbutic vitamin C, the lime is unexpectedly

Unfortunately the views of the majority of phys regarding the influence of anti-scorbutic foods rem vague and diffident, and scurvy continued to dev the mercantile marine until well into the 19th ce nor was the true cause realised until quite recent Yet as far back as 1841, the American doctor Bud ascribed the action of such foods " to an essential el which it is hardly too sanguine to state will be disc by organic chemists or the experiments of physiolog a not far distant future."

The first experiments on animals of the modern were performed in 1881 by Lunin at Basle. He fe mice on a diet containing every ordinary constitu milk in quantities quite sufficient to support life qualitatively so treated that the " freshness " destroyed. All the animals died and Lunin was observe that small quantities of substances, a unknown, were present in fresh food and " were ess to life." He had come upon what is now know Vitamin A. But what is perhaps the starting po our present considerable knowledge of the relation of diet to the deficiency diseases, and of the identifi and separation of the several vitamins, was the inve tion of the disease beri-beri. In 1897 Eijkman, a army doctor stationed in Dutch East Indies, proved beri-beri, a disease characterised by extreme la and debility, accompanied by an affection of the n and sometimes by paralysis, was solely dependent the consumption in large quantities of polished ri the staple diet. He had been sent over as a membe

ssion to study this disease which was then thought
acterial in origin. After the return home of the
ssion, he remained in charge of a laboratory, and
some fowls for investigation found it convenient
them on the scraps, chiefly of polished rice, thrown
om the hospital wards. The fowls presently
ed an illness with many of the symptoms of beri-beri,
which they recovered when no longer fed with
d rice, or when fed either with whole rice, or
olished rice to which an extract of rice polishing
en added. Eijkman at first suggested that the
was due to some poison in the polished rice, or to
of intoxication being set up by the consumption
essive quantities of starch, either of which was
ed by the natural antidote in the so-called "silver
which was removed in polishing. Later, led by the
hes of others he came to the conclusion that there
esent in the husk of rice grains a substance, small
unt, but absolutely essential to normal nutrition.
Funk who in 1911, after working on the causation
i-beri, coined the word "vitamines" as more
ient than the term "accessory food substances"
Hopkins had been using for a time, and under the
sion that they were nitrogenous compounds allied
amines. This has proved to be incorrect, and in
se the terminal "e" is now dropped and the
nces are now known as "vitamins."

very largely due to the methods of Gowland
ns of Cambridge University, who was afterwards
ed and received with Eijkman the Nobel prize for
ne in 1929, that the investigations on vitamins have
so fruitful. These investigations depended largely
feeding of animals on experimental diets, composed
ly purified material of proteins, fats, carbohydrates
inerals, to which were added or withheld certain
nces, very minute in quantity. The purified
ls taken alone wholly failed to maintain ordinary
n 1912 Hopkins published his classical experiments
h the addition of 2 or 3 cubic centimetres of fresh
the diet of rats fed upon normally balanced but



By courtesy of Cambridge University Press.

FIG. 11. Sir F. Gowland Hopkins, O.M., P.P.R.S.

artificial foods
an improvement i
rate of growth and
out of all proport
that shown in th
of the rats, which
only the milk. A
latter became
nourished, feeble
finally died. Th
prival of milk fro
normally developin
fed otherwise onl
the artificial diets
followed by failur
grow, debility and d
unless the milk wa
stored in good time

American work
Osborne and Mend
Newhaven, and McC
and Davis of Wisc
by their experi
proved that many
al foods such as
sugar, and butter-fat contained substances havi
marked influence upon growth and health, and that
substances could be extracted from the original foo
transferred to artificial foodstuffs, so making thes
growth-promoting and life-sustaining. The latter
investigators also proved that vitamins occurred in na
foods in different groups, some being "fat soluble"
others "water soluble"—a very useful experim
distinction. Thus they showed in 1915 that in ad
to the anti-scorbutic vitamin (vitamin C) there we
least two other vitamins, the first, contained in butte
"Fat soluble A" and the second contained not on
fresh milk sugar, but also in the wheat germ, rice polis
etc.—"Water soluble B." During the later stages
First World War, many intensive researches on nut

rried out, from which emerged chiefly, among natters, proof that rickets was caused by the from food and the system of a factor with certain ive features which justified its separation from oluble A" as "Vitamin D." After 1919 a vast of research was undertaken on vitamins in every country. This resulted not simply in the recog- of many more vitamins, and of the part played by the maintenance of animal metabolism, but also chemical composition and afterwards, in some their synthesis in the laboratory and manufac- on an industrial scale.

knowledge of vitamins has penetrated far from the ories of men of science and become in considerable e the common stock of information of the ly community. It has also been exploited by ers and distributors of fresh foods and manufac- of processed foods and medicaments. Dietetics has rofoundly affected by the recognition of the special ance of the different vitamins and of the advantage ticular foodstuffs in which one or other of them in relative abundance. It is not too much to that the discovery of the several vitamins and ctions, and the application of the discovery in es generally, is leading to a revolution in health and al welfare which will compare in magnitude and ance with that following the discovery of micro- ms as agents of disease.

ough deficiency diseases, with the exception of are practically unknown in this country in their forms, at any rate wherever an average mixed is followed, it is now generally accepted that a rable amount of ill-health is due to an insufficient of the various vitamins. The lack of appetite and vous and muscular tone, general debility and de, defects of bone and teeth, liability to such nal ailments as diarrhœa, constipation, gastric testinal dyspepsia, gastric and duodenal ulcers, etc., common among under-nourished or unwisely

nourished persons of the poorer sections of the comm
can be ascribed largely to inadequacy of vitami
deficiency in vitamins particularly affects the infa
child, and unfortunately the damage done at thi
early stage of development cannot be corrected ev
fully adequate food later in life.

At the beginning of the present century, ill-
dwarfed, bandy-legged, anaemic children, and adul
septic mouths and wretched teeth, were parti
numerous in the industrial regions of our country.
the increasing recognition of the place of the v
vitamins in the dietary, and the general applicat
knowledge to the feeding of the community at large,
is every hope that the reproach of the past will be forg
in the existence of a new generation, that will be
by inches, sturdier in frame and muscle, with jaws f
healthy teeth and countenances, clean and ri
Although much yet remains to be done, the past few
have shown a marked improvement in the ge
physique of the younger population of our country.

Vitamin A.
Anti-xerophthalmic, Anti-infective and Growth promoting.

This vitamin is found c
associated with animal fats an
particularly those occurring i
livers of fish, as the cod and ha
Eggs, milk, butter and chees
fairly rich sources, as are also many vegetables incl
spinach, watercress, lettuce, cabbage, carrot, green le
turnip tops and fresh peas. Cereals on the other
are poor sources; wholemeal, however, is better
white flour. Most vegetable oils, such as linsee
olive oil, and cotton seed oil contain little or
although some, as palm oil and maize oil, are good so

Vitamin A was first discovered and studied in cod
oil, but it was not until 1925 that it was distinguished
Vitamin D, which was associated with it in the or
"Fat soluble A."

Vitamin A plays an important part in the metab
particularly of young animals. Without it the grow
deposition of bodily tissues of any sort is impossible.

ular research, some rats were kept on a diet deficient
n A. They lived for 58 to 69 days, during most of
me they ate their food well and showed a moderate
t of growth, but during the last week or so of life,
te failed, weight was lost and finally death ensued.
the animals lack of fat and a general wasting of the
nes were marked features, and in addition nearly
one showed evidence of infection in some part of
body. A fair proportion developed either the
teristic inflammation of the eye—xerophthalmia—
ection in the urinary tract, intestines, lungs or ears,
ost suffered from abscesses at the base of the tongue
salivary glands. Vitamin A plays a primary role
aintaining the resistance of the body to in-
n: lack of it leads to degenerative changes in
pithelial cells which line the outer surface of the
and the moist inner surfaces of the respiratory tracts.

st of these results have been applied to man. Stunted
h and inflammation of the eye are often observed in
nourished children, especially in eastern countries.
health is brought up to normal when food rich in
in A is given them. Among adults a lowered
al tone of physical fitness follows a deficiency of
itamin in their diet; and connections with it and
e ear disease, pernicious anæmia and pneumonia
ot improbable. Lack of it may also cause night
ness—an inability to see in the darker twilight and
—or even full blindness. The vitamin has proved
of general value in the prevention of colds and other
ions of the respiratory tract—throat and bronchial
. Deficiency affects domestic animals also, such as
pigs and fowls, for these show most of the charac-
ic features of various forms of inflammation of the
elium, and of general debility if their food lacks a
iency of this factor.

amin A is closely related to carotene $(C_{20}H_{28})_2$ a
ative of chlorophyll, the green colouring matter of
s. The carotene content of plant food-stuffs
sponds very closely to their vitamin A content as
ured by experiments with rats. In rats carotene is

By courtesy of U.S. Bureau of Home Ec

FIG. 12. FIG. 13.

VITAMIN A.

Rats from the same litter, 11 weeks old.

FIG. 12. This rat had no vitamin A. It weighed only 56 g and had infected eyes, rough fur, and showed la vigour.

FIG. 13. This rat had plenty of vitamin A and weighed 123 g It had bright eyes, sleek fur, and was vigorous.

e of completely replacing the vitamin in their diet, t there are no symptoms of any of the usual defi- disorders. The feeding of rats suffering from n A deficiency with carotene is followed by the e of the vitamin in the liver and little or none of ne. Man is not so efficient a converter of carotene ; her appears that in his case vegetable vitamin A so readily absorbed as that of animal origin, and ore must needs be ingested in relatively larger ts to give equal effects. Any excess vitamin can red in the liver, kidney and depot-fat, from which be drawn as needed.

min A of immediate animal source is derived tely from the carotene of plants. The halibut, a ea fish, obtains its supply in the long run from e green organisms which float at or near the e of the ocean. Grazing cattle obtain their vitamin erbage and transmit it to their milk.

International Unit is 0·6 microgram. (A micro- is 1/10,000 milligram.)

---

y allowances are estimated as follows :—

Adult Man and Woman	...	3,500 to 5,000 I.U's.
Nursing Mother	... ...	6,000 to 8,000 I.U's.
Boy 10–12 years	... ...	4,500 I.U's.

Distribution of Vitamin A.

Foods.	*International Units per oz.*
but Liver Oil	600,000
Liver Oil	30,000
Liver	6,000–9,000
garine	450
ter	300–1,100
ese	370–1,600
-yolk	2,000–3,000
ot	1,700
ach	1,200
ercress	470
ato	280
ney	280
.. ..	60

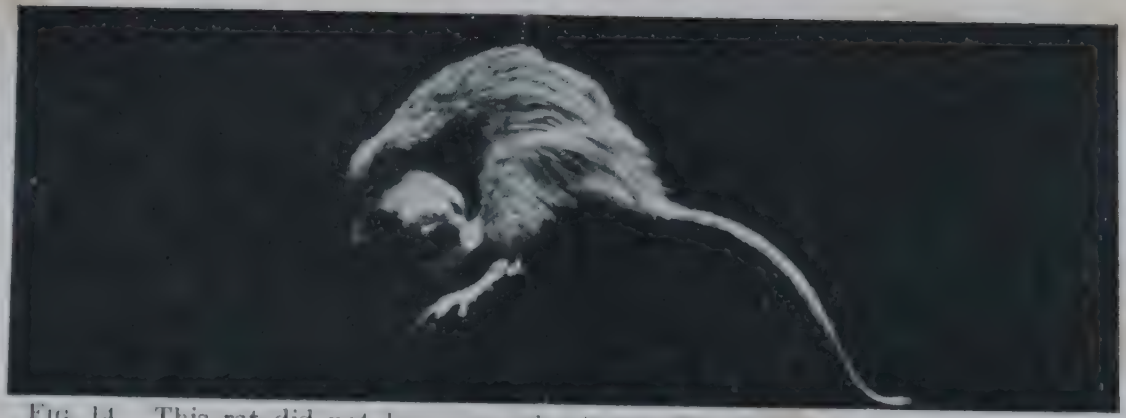


FIG. 14. This rat did not have enough vitamin B_1 and suffered from the lack of muscle control (spastic paralysis).

n B ex. The original "Water-Soluble B" of McCollum and Davis (1915) is now known to consist of a group or complex of several t substances which are usually, but not in every ssociated in the same foods. In 1920 the factor of ch was affected by heat was distinguished from a table factor: the former was labelled B_1—the anti-eri factor—and the other B_2. In 1933 B_2 was to consist of at least two distinct substances, one avin and the other P–P or Pellagra Preventive, now to be Nicotinic Acid or its amide. Other con-nts of the B Complex have been distinguished from o time in their relation to particular disorders in arious test-animals. Among these B_6 (Pyridoxin) and Pantothenic Acid are recognised as being ial to the proper functioning of the system.

FIG. 16. Crystals of vitamin B_1.

Vitamin B_1 Aneurine (Thiamine) The absence of this nutrient from staple diet of rice of millions of the p populations of the East has long been r nised as the cause of beri-beri, a di which causes more ill-health and untimely death perhaps any other single disease. Eijkman showed this deficiency disease is due to the lack of a factor f in the husk and " silver skin " of the rice grain, bu moved in the preparation of the rice for consump Similarly in the milling of wheat grains the removal o husk as completely as possible so as to prepare the w flour generally demanded by people with a higher stan of living, vitamin B_1 with other nutrients is lost to consumer. If he depends upon bread as his chief so of energy, he may run dangerously short in protec foods and suffer from mild forms of nervous disor Marked deficiency, as among the heavy consumer polished rice, causes polyneuritis, a disease of the ner tissues, and beri-beri, the chief symptoms of which loss of feeling, wasting of the muscles and tissues gener paralysis and death. Lack of the vitamin in a less de as among the poorest of our population, for whom b is the main support, shows in a variety of disord lack of appetite, nausea, general low state of bodily fit and efficiency, impaired morale, nervousness, and orders of digestion and elimination generally.

An unfortunate event in the First World War, failure of first stage of the Mesopotamian campa arose out of the fact that our soldiers were fed on ti meat—" bully beef "—and white biscuit, when owin difficulties of transport there was a shortage of fresh f As a result beri-beri broke out. Vitamin B_1 was lac in the biscuits, which had been made from white f The disease cleared up when small quantities of y paste were served with the beef and biscuits. In Second World War the importance of vitamins in m taining all-round fitness being fully recognised, in addi to fresh food, biscuits and other articles of food fort with several vitamins were regular items of the dieta the field.

urine is concerned with the burning in the tissues red carbohydrates, and so with the liberation of . It is associated with a compound of phosphorus oxidation of pyruvic acid, an immediate oxidation ct of lactic acid, which itself is one of the first pro- of the breakdown of tissue-carbohydrate. A ency of the vitamin results in the accumulation of the ic acid, which occasions various nervous systems— bility, insomnia, bad temper, quickening of the beats and afterwards dilatation of the heart. As soon is given in sufficient doses tissue-combustion es normal and the nervous symptoms subside.

urine has a formula $C_{12}H_{17}N_4S\,O\,Cl$. It is manufactured on scale as an ingredient of mixed vitamin preparations.

urine is found most abundantly in brewer's yeast. The outer gs and germ of cereals contain most of the vitamin content of ains; the endosperm has little. The vitamin is found in ruits and vegetables.

International Unit of Aneurine (Thiamine) is 3 micrograms synthetic substance.

(1 mg = 333 I.U's.)

allowances in milligrams are as follows :

Man—	
Sedentary	1·0—1·5
Very active	1·6—2·3
Woman—	
Sedentary	0·8—1·2
Nursing	2·8
Child, 10–12 years	1·2
Boy—	
13–15 years	1·6
16–20 years	2·0
Girl—	
13–15 years	1·4
16–20 years	1·2

Distribution of B_1 (Aneurine).

Food.	*International Units per oz.*
Bemax	300–400
Marmite	100–300
Dried Yeast	190
Bacon and Ham	100
Oatmeal	90
Liver	50
Butter Beans	45
Breakfast Oats	40
Egg Yolk	40
Lettuce	25
Prunes	25
Beef (lean)	20
Potato	12
White Bread	3–9
Milk	7
Sugar	0

Vitamin B_2 (G) Riboflavin. Like all other vitamins of the B C plex this nutrient is soluble in w With Nicotinic acid it is more heat st than B_1. The effect of the original heat-stable B_2 fa on the growth of rats was found to be distinct from effect on pellagra symptoms, and was due to the crysta substance isolated in 1933, from egg white, milk and and originally labelled ovoflavin and lactoflavin, bu being found to contain a five carbon chain sugar-rib was renamed riboflavin. It was synthesised in 1934 is now manufactured on an industrial scale.

Riboflavin is a yellow pigment with a green fluoresc which gives whey its yellowish green tint. Its formu $C_{17}H_{20}N_4O_6$.

A shortage of Riboflavin causes failure of the appe stunted growth, cracks and sores about the nose corners of the mouth, digestive disturbances, ner weakness and increased liability to infection. It is li in its action in the system with a derivative of phosph and a protein, to form a substance which is essentia the oxidation of tissue-carbohydrate and so to the m tenance of energy, upon which life itself depends.

ed that the appearance of premature old age is due ficiency of this vitamin and that with good supplies food or otherwise, greater vigour and better health

brewed with yeast naturally contains some of the ns associated with yeast—Riboflavin and Nicotinic Biotin and Pantothenic acid. The relative immun- this country from clearly marked symptoms of ncy condition may, it is suggested, be well due to the l consumption of beer, to which might also be tea, which beverage also contains appreciable nts of Riboflavin.

ious commercial meat extracts have proved on sis to contain significant amounts of Riboflavin and nic Acid, as might be expected from their manu- e by the leaching out of all soluble extractives from neat.

Daily requirements of Riboflavin in milligrams.

Man—	
Sedentary	1·5—2·2
Very active	2·3—3·3
Woman—	
Sedentary	1·3—1·8
Nursing	3·0
Child, 10–12 years	1·8
Boy—	
13–15 years	2·4
16–20 years	3·0
Girl—	
13–15 years	2·0
16–18 years	

Distribution of Riboflavin in Mg. per oz.

Food.	*Mg. per oz.*
ed Yeast	0·9—1·4
er	0·4—0·8
t Extract	0·5
... ...	0·06
olemeal Bread	0·05
ite Bread	0·01

VITAMIN B_2. (G)
Male rat, 28 weeks old.

FIG. 17. This rat had no vitamin B_2 (G) and weighed only 63 grams.

ic Acid In 1915 pellagra was known to be a
1). food deficiency disease. In 1937 nicotinamide, the amide of nicotinic acid, olated from a liver extract and shown to cure lack tongue in dogs and pellagra in human beings matter of a few days. Nicotinic acid is y effective.

agra is a disease which is widespread among the sections of the population in U.S.A., chiefly in the ern States where the food staples are the "three —Maize, Molasses and Meat (salt pork). In the 1911-16 more deaths were recorded by the Metron Life Assurance Co. of America from pellagra than general tuberculosis and malaria. The usual oms of pellagra are skin eruptions (especially where ed to light), sore tongue, muscular weakness, gement of the digestion and elimination, nervous ions and in extreme cases, dementia.

otinic Acid is a derivative of pyridine and like the vitamins of the B Complex plays an essential role liberation of energy from the cell and tissue carbotes. The amide is found in all living cells.

Daily Allowances of Nicotinic Acid in Mg.

Man—	
Sedentary	10–15
Very active	16–23
Woman—	
Sedentary	8–12
Nursing	18–23
Child, 10–12 years	12
Boy—	
13–15 years	16
16–20 years	20
Girl—	
13–15 years	14
16–20 years	12

Distribution of Nicotinic Acid in Foods

Foods.	*Mg. per oz.*
Dried Yeast	21·8
Meat Extract	17·0
Liver, Kidney	3·8
Peanuts	2·6
Salmon	1·8
Soya	1·2
Beef, Bacon	1·3
Wholemeal Bread	0·6
White Bread	0·2
Watercress	0·5

Vitamin C Ascorbic Acid. A continued deficiency of the vita in the dietary brings on scurvy—in times the scourge of undernouri people generally. It was an especial plague among farers on long voyages between landings when it difficult, if not impossible, to get fruit or green vegeta Many expeditions were so brought to disaster.

The characteristic symptons of scurvy are tender of the joints and jaw, bleeding of the gums and loose of the teeth, loss of appetite, and bleeding under the of the trunk and limbs and into the joints. More com among sections of the population with a low standar living than the acute forms of scurvy are a retarded gro low state of health and poor resistance to infection slowness in recovery from illness; bones lose calci becoming porous and brittle, and wounds and fract take long to heal.

The importance of ample supplies of the vitamin growing children is now fully recognised by the Stat its encouragement of the consumption of preparation rose-hip extracts and blackcurrant puree. These fr are particularly rich in ascorbic acid, even more so t citrus fruits—orange, lemon, grape fruit, etc. Fruit vegetables in which active metabolic processes are proce ing are the richest sources of the vitamin, but in amou varying widely as between one family of plants and anot closely related and one species and another of the sa

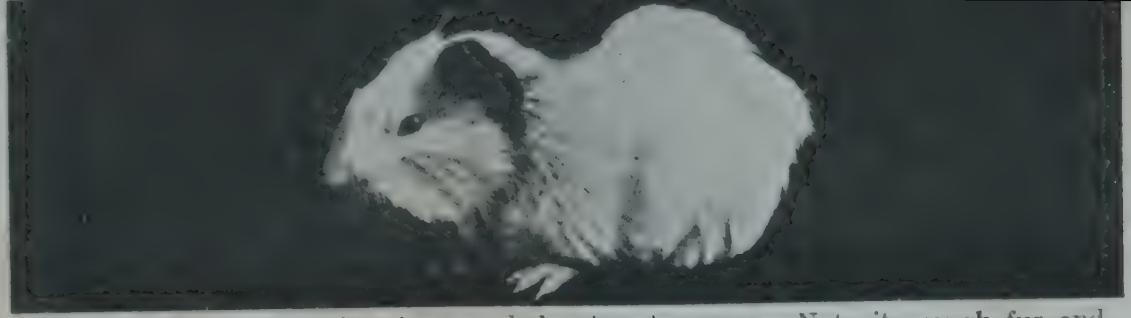


FIG. 19. This had no vitamin C and developed scurvy. Note its rough fur and crouched position due to sore joints.

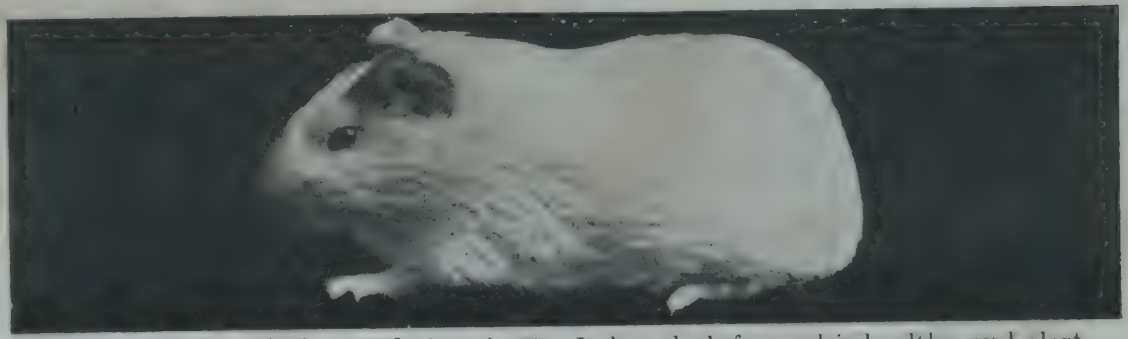


FIG. 20. This had plenty of vitamin C. It has sleek fur and is healthy and alert.

By courtesy of U.S. Bureau of Home Economics.

genus. Citrus fruits and tomatoes are better prot against scurvy than cherries, plums and peaches rose family, and among the citrus group, lemo oranges are much superior to limes. The juice of fruits deteriorates on keeping and lime juice as u sold has but little anti-scorbutic value. Resting tissues as in seeds are lacking but when germinat five days, the legumes–peas, beans, etc.—become n ably rich in C. Tomatoes ripened on the plan particularly rich, and if allowed to ripen after being pl are almost equally effective, though when green a little value. The soft fruits, as strawberries and berries, are rich. Eggs and cereals usually contai vitamin C, unless in the latter case germination begun. Meat is a variable source, although when fre has some value. The value of cow's milk is very var with the season of the year and the character of herb Milk loses any of its vitamin if exposed to sunl

Canned fruits and vegetables as now processed contain anything between 50 and 100 per cent. of vitamin in their fresh condition.

It is characteristically more easily destroyed than other vitamins. It is most susceptible to heat, therefore green vegetables and fruit containing it a possible best eaten raw. When vegetables such cabbage, spinach, turnips and peas must be cooked should be for as short a time as possible. A high temp ture quickly attained is better than a moderate temp ture slowly attained. Oxygen is apparently a active factor in the destruction of this vitamin. This explains why dried vegetables are usually ineffec against scurvy. Sodium carbonate being an al destroys the vitamin even in the cold and therefore sh not be added to greens or peas with a view to impro their colour in cooking. Chemical preservatives w added to fruit juices and syrups destroy the vitamin.

Ascorbic acid has the formula $C_6H_8O_6$. It is a derivative o hexose sugar, mannose. Its most remarkable property is exceptionally high reducing power, to which may be ascribe rapid destruction by oxidation during the cooking of mate passably rich in it when exposed to the air. It is also qu

d by the enzymes liberated from the tissues of vegetables ese are cut up or bruised in preparation for cooking.

Daily Requirements of Ascorbic Acid in Milligrams

Man—	
Sedentary	75
Very active	75
Woman—	
Sedentary	70
Nursing	150
Boy—	
10–12 years	75
16–20 years	100
Girls—	
16–20 years	80

. Distribution of Ascorbic Acid (Mg. per oz.)

kcurrant	65
bage	20
liflower	20
ercress	18
nach	17
nge	16
pefruit	15
non	12
green	8
nato	7
ato	2–8
ana	3
le	1
... ...	0·3

n D— achitic n.

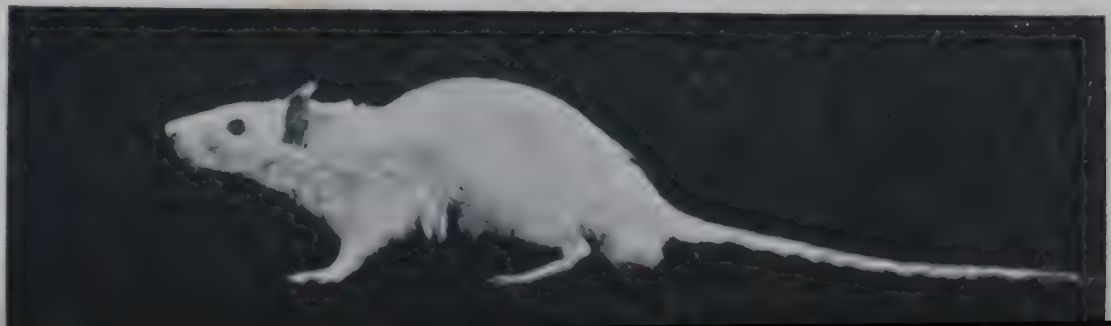
The anti-rachitic vitamin is generally associated with the other "fat soluble" vitamin A, and like it is found in animal fats and milk and in particular abundance oils of fish-livers, as of cod and halibut.

min D is closely concerned with the calcium phos- metabolism of the body; when it is deficient rickets p, and there is failure to develop bone and teeth. isease can be prevented or cured by the operation mplex of factors, of which vitamin D is one, and the of calcium and phosphorus in mineral form is r. Vitamin D may be supplied to the system ways, either in certain classes of food or by

VITAMIN D.

Rats from the same litter, 20 weeks old.

FIG. 21. This rat had no vitamin D and showed the short body and bowlegs typical of rickets.



tion within the body itself by adequate exposure
nlight or ultra-violet light. Before the relation
en the two had been established, there were two
t schools of thought; one the Glasgow school,
ng the importance of light and to a scarcely less
of fresh air and exercise also, and the other that of
ns and Mellanby, laying most emphasis on the proper
These two are now in agreement, for it appears
he shorter light waves, whether of bright summer,
sky light, or as emitted in great intensity from the
ry vapour lamp, have the power of converting into
tamin D a precursor or parent substance, cholesterol,
is present with fat in most animal tissues.

vas Mellanby who in 1918 first stressed the fact that
ciency of a fat soluble vitamin played an important
n causing rickets, and that if a young animal were
ied with a sufficiency of the vitamin, rickets would
evelop. Almost contemporaneously it was discovered
exposure to sunlight or to the ultra-violet rays of
ury vapour quartz lamps could cure rickets in children
ell as in young animals. Infants fed on a diet
ent in vitamin D developed the disease in winter
and not in summer, and further could be cured in
r by exposure to suitable radiation or by the
nistration of cod liver oil without any other change
heir food or general hygiene. Children supplied
cod liver oil were quite free from rickets. Experi-
s on rats also showed that animals fed on food
ent in the vitamin escaped rickets if they had
ar exposure to sunlight or ultra-violet radiation,
f they were kept in the dark they developed rickets.
the other hand the diet was rich in vitamins including
he rats did not develop rickets even if kept in
ark.

habitants of the tropics, with an unprotected skin,
gh living largely on maize meal, have well developed
s and teeth, but when they adopt European clothes,
re kept closely in doors, especially from childhood,
r from rickets and dental decay (osteomalacia).

Ergosterol, with which vitamin D is also very intima related, is widely distributed among the algae and suc the plankton as contain chlorophyll. It is upon these forms of aquatic life that all fish are ultimately depen for their food, and from which they derive vitamin Green land plants are poor in ergosterol and vitamin but the amount can be increased by exposure to ul violet light and is consequently larger in summer pastu than at other times.

When ergosterol is present in natural foods its expos to ultra-violet rays definitely increases its anti-rach power. Some yeasts are rich in ergosterol and by irra tion increase very considerably in the vitamin value that they far exceed cod liver oil. A product of irradia ergosterol, when this is subjected to fractional sublimat in vacuo, is a crystalline compound, known as "Calcifer Its potency is extraordinary; one ten-thousandth o milligram a day added to the vitamin D-free diet of a will entirely prevent the appearance of rickets. Calcif ($C_{28}H_{44}O$) has the same molecular weight as ergoste from which it is doubtless converted by a rearrangem of the intra-molecular linkages. It is remarkably sta under ordinary conditions, but loses its activity wh heated to 180°C., or subjected to further irradiation w ultra-violet light; in the latter case it does not reg activity on standing. Irradiated ergosterol, or Calcife is called D_2 and the vitamin found in cod liver oil distinguished as D_3. Crystalline vitamin D_2 has beer commercial commodity since 1932 and is used to fort margarine.

Irradiated ergosterol will cure rickets in an animal simply rubbed into a broad patch of skin. Exposure sunshine, in sun bathing or to rays from a mercury lam results in the generation of the vitamin D from t sterol in the superficial layers of the body, largely in t subcutaneous fat. The vitamin diffuses from the area formation throughout the system, so that exposure of t whole body is really not necessary to ensure a sufficie dosage of the vitamin.

effective rays of sunlight are the shorter wave
s beyond the visible spectrum. These are very
y absorbed by the atmosphere when the sun is
bove the horizon, as generally in the winter months,
xcept in the mid-day hours in summer. They are also
y absorbed and scattered by the smoke and dust of
tmosphere of industrial regions. Ordinary window
absorbs the shorter ultra-violet rays, but "vita
" allows them to pass through. It is for this reason
vita glass is used in solaria and in schools. Such
must, of course, be kept clear of deposit, and in any
cannot serve its special purpose on dull days or
the atmosphere is hazy with fog or smoke.

e source of the increased amount of calcium in the
following the administration of vitamin D is still a
r for experiment. It would appear most probable
he vitamin operates by increasing the absorption of
m and phosphorus from the intestines. It has
asserted that when too much vitamin D is adminis-
the increased calcium is taken up from the bones.
the diet is rich in calcium the bone stores are not
called upon for supplying this element owing to
ncreased absorption from the intestines.

Daily Requirements of Vitamin D in International Units
0·025 micrograms of Calciferol.

For infants, and nursing women : 400 to 800 units.
For children and adults : 400 units and upwards.

Distribution of Vitamin D in Foods.

Food.	*I.U's per oz.*
d-liver Oil	3,000
rring	150–300
dines, canned	150–300
mon, canned	150–200
ckerel, fresh	350
g yolk	50–150
tter	10–20
eese	17
k, dried	3
reals, meats, vegetables, fruits	Nil

SUMMARY OF VITAMINS.

Vitamin.	*Roles.*	*Chief Sources.*	*Daily Re*
A Carotene ($C_{20}H_{29}OH$)	Growth promoting. Protective against xerophthalmia and night-blindness, and against infections of skin and respiratory epithelium.	Halibut liver oil Cod liver oil. Carrot. Spinach. Egg-yolk. Liver. Kidney.	Adult : 3.5 Child under 1.5 Child 13–20 5.0
B_1 Aneurine (Thiamine) ($C_{12}H_{18}SON_4Cl_2$)	Growth-promoting. Anti-neuritic. Protective against Beri-beri.	Yeast. Pea-nuts. Pork. Wholemeal. Egg. Potato.	Adult : 1·2 Child under Child 13–20
B_2 Riboflavin ($C_{17}H_{20}N_4O_6$)	Growth promoting. Anti-dermatitic.	Yeast. Liver. Kidney. Meat extract. Cheese. Egg.	Adult : 2·2 Child under Child 13–20
Nicotinic Acid or Amide ($C_6H_5O_2N$)	Growth promoting. Pellagra preventive. Anti-dermatitic.	Yeast. Meat Extract. Liver. Kidney. Pea-nuts. Wholemeal. Meat.	Adult : 15–2 Child under Child 13–20
C Ascorbic Acid ($C_6H_8O_6$)	Growth promoting. Anti-scorbutic. Protective against infection of mouth.	Rose Hips. Black currant. Cabbage family. Citrus fruits. Watercress. Potato.	Adult : 70–7 Nursing moth Child under 1 Child 13–20
D D_2 Calciferol ($C_{28}H_{43}OH$) D_3 Natural Vitamin ($C_{27}H_{43}OH$)	Bone formation. Protective against Rickets.	Cod liver oil. Herring. Salmon. Sardine. Mackerel. Egg.	400–800

CHAPTER IX.

FOOD MINERALS.

body requires continually not only foods consisting
e main of proteins, fats and carbohydrates, to
ain growth, to repair wastage, and to supply energy,
lso foods which contain in much smaller quantities
dozen or so mineral elements, in the form of salts.
mineral substances are needed for a variety of
ses, although at the most their quantities are
vely small. The calcification of the bones, upon
and within which the soft tissues—muscle, nerve,
ctive tissue, blood, etc.—are formed, calls for the
nts of calcium and magnesium phosphates and
nates. Mineral elements and groups are also
ary necessities as assistants in all the processes
cteristic of the living organism—respiration, diges-
movement and general metabolism. Without the
of certain elements, the ordinary life of even the
simple organism, and the smallest cell within an
ism, would be impossible. Salts apart from helping
rm the phosphates and carbonates of the skeletal
ework do not build up tissue, nor can they yield
y by any process of oxidation.

nen the body is finally reduced to its inorganic residue,
by incineration or ultimate decay, and the ash is
sed, this is found to consist of compounds, in the
, of the following mineral elements; phosphorus,
m, magnesium, potassium, sodium, iron, chlorine
iodine: there are also much smaller quantities of
inorganic elements, such as fluorine, copper, zinc,
anese, cobalt and arsenic. Five-sixths of the
ral ash is derived from the bones, and the remaining
sixth in varying proportions from the soft tissues.
s, when fresh, contain only 35 per cent. mineral
er, the rest is organic matter and water: incinerated
ash contains some 84 per cent. calcium phosphate,
n the residue, other salts of calcium and magnesium,

The phosphorus of the body is also chiefly in the b
but one quarter of the total amount is associated wit
soft tissues—muscle, nerve and blood. Sodium
potassium in various compounds play an important
in maintaining the alkalinity of the blood and cell f
generally. Iron is an essential ingredient of the hae
globin of the blood, upon which the whole proces
respiration depends. Chlorine combined as hydroch
acid is necessary to peptic digestion. Iodine is impor
as the largest component of thyroxine, the hormone of
thyroid gland, the central exchange of the endoc
system with the proper functioning of which as a wh
the health of the system is closely bound. In t
several ways and degrees the mineral elements play t
parts in maintaining life, and must therefore be provi
insufficient quantities in the food ; the deficiency of
one of the elements listed disturbs the balance of
whole, resulting in disorder or worse.

The mineral elements are ingested either as parts
complex organic compounds, as are sulphur and ph
phorus in certain proteins, or in simpler organic forms
the cell sap and juices of animal and plant tissues ea
as foods, or in simple inorganic compounds dissolv
in drinking water and beverages. The average w
balanced diet of fresh animal and plant food is abunda
and varied enough to supply all the mineral eleme
required to maintain the body in activity and heal
But diets may be followed unwisely, or in certain circu
stances of necessity, which though providing ample grow
and energy substance, and even not deficient in any
the several vitamins, are yet seriously lacking in one
other of the essential mineral elements, and in consequen
fail to maintain health.

Sodium and Potassium. These elements are taken in
the system by way of ordina
food consisting of the tissues of animals (chiefly as sodiu
and plants (chiefly as potassium), and by way of comm
cooking or table salt. Sodium and potassium chlorid
supply chlorine for the formation of the hydrochlo
acid in the gastric juice, in the presence of which pep

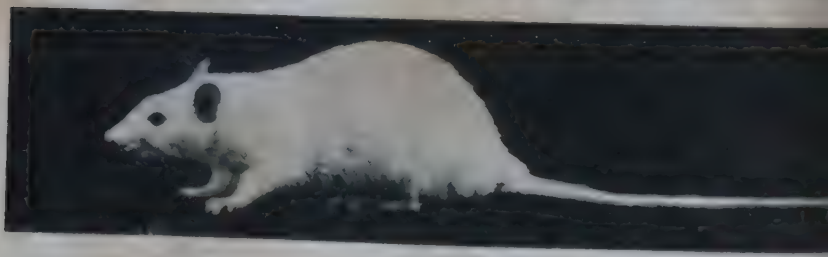
on proceeds. Much salt is excreted from the blood sweat glands in perspiration and by the kidneys in some 10 grams daily. Where a salt-free diet is d experimentally the amount secreted can be l to 0·1—0·2 gram. If perspiration, and so loss , is excessive (18 lbs. of sweat contains $1\frac{1}{2}$ ounces and much water is drunk in replacement of the excreted, the concentration of salt in the blood is d to such an extent as to give rise to muscular . Miners working in hot mines and stokers on are therefore advised to add salt to their drinking and to eat salt foods such as bacon or kippers. s retained in the system during high fever, as in nonia, and is released only when the crisis has passed. atural satisfaction to ourselves and to animals a n saltiness of food gives, may be taken as indication alt is essential to the physical well-being. Salt-licks sually provided for cattle as supplementary to the sium salts they obtain by eating grass and roots. far excess of salt is a disadvantage, if at all, is not ttled ; it may on occasion even serve to prevent ecretion of hydrochloric acid in the stomach. Both m and potassium, in combination as carbonates hosphates, ensure the alkalinity of the bile. This an important part in neutralising the acid chyme passes from the stomach into the duodenum, and in quent digestion by the pancreatic enzymes, which quire an alkaline medium. The two sodium phos-s, Na_2HPO_4 and NaH_2PO_4, play an equally important n maintaining the proper degree of alkalinity in the . Potassium and sodium are not altogether inter-eable ; the former relative to the latter is more dant in the actively growing and secreting tissues in the blood and supporting tissues. Although sodium than potassium is ingested, the balance n the body is effected by its more abundant excretion rspiration and urine.

um. This element is found everywhere in the body, playing different but primary roles in veral tissues. Of dried bone, 67 per cent. is mineral

matter and towards 90 per cent. of this is calciu phosphate and carbonate. Teeth contain a still h proportion of mineral matter, of which calcium is the chief constituent. The element in some combin or other is concerned with the carrying throug practically every chemical and physical reaction i ultimate cells. It is necessary for the clotting of and lymph, for the closing of wounds in the presen air, and for the clotting of milk in the presence o gastric enzymes. It maintains the excitability of nervous system so that nervous impulses are condu When it is deficient, muscles lose their tone, first beco hyper-excitable and finally palsied. That the contr calcium metabolism is of first importance is evident the fact that two pairs of the endocrine glands, parathyroids, are largely concerned with it, through agency of the hormone they secrete. A sympton parathyroid deficiency is the lowering of the calc content of the blood. In the case of parathyroid tum

Rats from the same litter, 22 weeks old.

FIG. 23. This rat lacked calcium. It weighed 91 grams showed the short stubby legs due to poorly formed bo



By courtesy of U.S. Bureau of Home Econom

FIG. 24. This rat had an abundance of calcium. It weighed grams and its bones were well formed.

blood content of calcium is maintained, but at the
of the calcium in the bones, which consequently
and lose their rigidity and strength. Whenever
se the body is not supplied with a steady and
t supply of calcium a similar withdrawal takes
om the bones, serving as a store. The deposition
um phosphate in the formation of bone, in place of
e, depends upon the presence of a specific enzyme,
atase, which operates upon the super-saturated
of the two elements in organic combination in
od. Vitamin D also participates as a necessary
n the process of the deposition of calcium phosphate
bone. A metabolic disturbance, which may be
closely related to a modification of endocrine
, results in the deposition of bone compounds
re than the skeleton ; as for example in the blood
: the walls then become non-elastic, brittle and
o breakage—all symptoms of arterio-sclerosis.
n born, infants have a skeletal framework that is
entirely one of cartilage. In the course of develop-
he cartilage is largely replaced by bone, in which
alcium phosphate and carbonate are incorporated.
e formation of bone and teeth the system must be
nd continuously provided with much calcium and
orus and these in an assimilable form, as naturally
, and in addition with sufficient vitamin D (see
09), failing either of which the condition of rickets
enes. The diet of nursing mothers should therefore
ched beyond the ordinary with calcium-rich foods,
as D. The average daily requirement is 1 gram
adult.

ium. This element occurs to some limited extent in replacement of calcium in the bones and
s. How far it is a necessary ingredient on its own
t or may be replaced by calcium, is not plain.
ccurs in very small proportions in the ash, but
yet appear to play an important role in the meta-

orus. This occurs everywhere throughout the system. It is an ingredient of the phos-
of calcium and magnesium in bone and teeth, to

the extent of three-quarters of the amount. It occ
an essential component of the higher proteins, such
nucleo-proteins of cell nuclei, and is therefore com
tively abundant in nervous and glandular tissues.
component of other proteins as hæmoglobin, casei
albumin. Phosphorus is also an ingredient of the li
such as lecithin, and is found as a double phosphate
glucose in muscles, where it is antecedent to the
acid, which appears as a product of muscular contra

Rats from the same litter, 9 weeks old.

FIG. 25. This rat did not have enough phosphorus. It
slowly and weighed only 60 grams.

FIG. 26. This rat had plenty of phosphorus and weighe
grams.

By courtesy of U.S. Bureau of Home Econom

The sodium phosphates in the blood salts, toge
with the carbonates, play a very important role in m
taining the body neutrality as "buffer" salts.
neutrality is continually being disturbed, both gener
and locally, by the common body functions of digest
assimilation, respiration, secretion, metabolism, m
ment, etc. Food, as taken in, may be acid, neutra
alkaline; digestive secretions are variously acid
alkaline; respiration and exertion produce acids in
blood, such as lactic and carbonic; metabolism of

s yields alkaline substances from the amino groups
id substances from the carboxyl groups and from
r and phosphorus. The cell protoplasm is peculiarly
re to the degree of acidity or, as matters usually
, of alkalinity of the cell sap. A slight decrease of
ity beyond a critical value may mean death,
gh an increase of alkalinity is tolerated over a
vide range.

i is slightly alkaline at a value expressed by pH-7·4 where
ty is pH 7·0. Although life is possible in the range pH 7·0
9·0, that is on the alkaline side of neutrality, the practical
the case of man is very small indeed, round about pH 7·4.
sition is maintained by the joint and correlated actions of
d salts, respiration, the liver, the kidneys, and the intestines.
mong the blood salts are the two phosphates of sodium
O_4 and NaH_2PO_4, the former alkaline and the latter feebly
These two act as "buffer" salts, so that the addition to
nder ordinary circumstances of metabolism of either acid or
nakes little or no difference in the pH value of the blood.
rease in the concentration of hydrogen ions by the addition
id such as hydrochloric or carbonic acid, is quickly nullified
raction with the alkaline phosphate Na_2HPO_4 resulting in
nation of the slightly acid phosphate NaH_2PO_4

HPO_4	+	HCl	=	NaH_2PO_4	+	NaCl
line		Well ionised		Feebly		Neutral salt.
phate				ionised		

imilar fashion carbonic acid yields with the alkaline phosphate
l phosphate and the feebly alkaline sodium bi-carbonate.

$$Na_2HPO_4 + H_2CO_3 = NaH_2PO_4 + NaHCO_3$$

ochloric acid, or rather hydrogen and chlorine ions, are
d in the blood by the interaction of the fully ionised sodium
, NaCl, with the carbon dioxide, CO_2, liberated in the course
ation within the tissues.

$$NaCl + H_2CO_3 = NaHCO_3 + HCl.$$

ncrease in alkalinity on the other hand is checked by the
ion of the acid phosphate NaH_2PO_4 to the alkaline phosphate

$$NaH_2PO_4 + NaOH = Na_2HPO_4 + H_2O$$

acid phosphate NaH_2PO_4 is chiefly responsible for
ghtly acid reaction of urine, for in the average diet,
food containing proteins predominates, and these

yield acids on oxidation. If on the other hand veg foods are eaten in excess, the excess alkalies are got by way of Na_2HPO_4. Excess phosphates in the follow upon any unusual mental strain, as in stu worry or other forms of nervous wastage: they also in wastage diseases when the proteins of muscular t are being destroyed.

The chief source of food phosphorus is the prote animal and vegetable tissues. Milk, cheese and eg well as glandular tissues, such as sweet-bread, provid element in a concentrated and assimilable form in or combination. Salts dissolved in the tissue fluids second natural source. Phosphorus can apparentl assimilated in the form of calcium phosphate when n with foods, but it is not yet agreed whether it ca absorbed generally in an inorganic state. On occasio we have seen before, the bones serve as a store or rese of phosphorus equally with calcium.

The daily requirement of phosphorus is 1·23 gr.

Iron. Iron is a necessary component of the colou matter, hæmatin, of the hæmoglobin in the blood corpuscles. Hæmoglobin has the power of bining loosely with oxygen, and so enabling it t conveyed from the lungs, where it is taken in from atmosphere, to the ultimate cells of the tissues, w it is concerned with the liberation of energy f organic substances. Deficiency of iron in the food m therefore a deficiency of hæmoglobin and a conseq slowing down and enfeeblement of the metabolic proce characteristic of anæmia; which state is therefore o relieved by a diet rich in iron salts. Iron can be ass lated in both the inorganic form, as found in the wate chalybeate springs, and the organic form, as in ri green vegetables such as spinach and watercress, or in livers of food-animals. Milk is very deficient in i cow's milk even more so than human milk, and wer not for the fact that an infant is born with a store iron in the liver its milk food would have to be comp sated in respect of iron even earlier than is usual. Grow

n drinking much milk should take also greens, and uits as almonds and raisins, which are particularly iron. Although milk is itself very poor in iron, has the property of rendering more effective the other foods. The daily requirement of iron for an s 0·013 gr.

ens—Chlorine, Bromine and Iodine.

rine combined as the chlorides of potassium and n is found throughout all the body tissues, and as a nent of hydrochloric acid in the gastric juice. It ived from most fresh foods and from ordinary g salt.

occurrence of iodine in the system is bound up intimately with the activity of the thyroid gland, is found on either side of the larynx, in its formation roxin, a substance containing some 60 per cent. by of the element. Whenever thyroxin is not secreted assed into the system, disorders follow. A child be born or shortly develop as a cretin—a dwarfed characterised by a clumsy stunted figure with flabby eavy features, void of all distinctly human intelli—and will continue so for the rest of life unless it es that this distressful state can be wholly corrected iet of thyroid extract. Another distressing disorder nd amongst adults as goitre, the features of which welling of the neck, pallor and flabbiness of counten- loss of hair and dullness of intellect. It is a common nt in districts or countries where for some reason or there is a definite shortage of iodine in the drinking , such as in limestone dales of the Pennines and ps, and in certain valleys of Switzerland and Bavaria. er to correct this local or regional liability to goitre, s of potassium or sodium are now purposely added food in the form of iodised salts, sweets or chocolates. r carrying salt spray is comparatively rich in iodides, onsequently goitre is very rare on the coast. But y the iodides and other sea salts are washed clear the atmosphere by rain before the winds have

penetrated far inland. It has however been obse
that during heavy south-west gales the concentratio
salt in inland reservoirs amongst the Pennines defin
increases.

The thyroid secretion plays several important roles in the c
ical reactions within the body. It controls the rate of destru
metabolism, and so of the intake of food and the output in en
If thyroxine is secreted in too great a quantity general metab
is speeded up ; the heart beat is very rapid, the nervous sy
highly excitable and perspiration profuse. Thyroid deficiency
the other hand, is accompanied by a slow pulse, low body tempera
and a failure to burn fuel, with a consequent deposition of
Thyroxine would also appear to determine the times of the se
climaxes which mark the several successive stages of adolesce
maturity and failure of bodily powers. Experiments on tadp
of amphibians show that metamorphosis is closely dependent u
the activity of the thyroid gland. If the glands of a tadpole are
out, the usual change to a frog fails to take place, so that the an
may continue to grow as a tadpole for years, indeed indefinitely
if it is kept supplied with water with no trace of iodine. On
other hand a large American species of frog, which usually ha
tadpole life of two years, when fed on thyroid gland turns into a
after six weeks only from hatching.

Foods rich in iodine are the liver oils of fish, the flesh of sea
generally, sea kale when grown near the sea, and in less deg
milk.

Bromine has been found in the adrenal and pituitary glan
deficiency is said to cause death in the second generation of rats.

Rarer Mineral Elements. Small traces of copper, manganese a
zinc found in certain foods would seem
play essential roles in metabolism.

Copper appears necessary to the formation of hæmoglob
as assistant to iron. There is evidence that cobalt, whi
is invariably present must co-operate with copper in th
process.

Manganese. Although this metallic element is found
very small amounts in the ultimate ash, it is thought
play a particular role in the activities of the reproducti
glands. A failure of the maternal instinct in rats h
been related to a deficiency in this element.

TABLE.

cons'ituents in 100 grams of Edible Portions.

(*After Sherman.*)

	Calcium.	*Potassium*	*Phosphorus*	*Iron*
...	0·120	0·143	0·093	0·00024
lk ...	0·137	0·115	0·524	0·0086
ite ...	0·015	0·160	0·014	0·0001
...	0·931	0·089	0·683	0·0013
lry) ...	0·084	0·903	0·400	0·0057
es ...	0·014	0·429	0·058	0·0013
e ...	0·045	0·247	0·029	0·0011
...	0·056	0·287	0·046	0·0006
n ...	0·067	0·774	0·068	0·0036
ds ...	0·239	0·741	0·465	0·0039
...	0·007	0·127	0·012	0·0003
...	0·064	0·820	0·132	0·0021
(white)	0·027	0·108	0·093	0·0009
al ...	0·069	0·344	0·392	0·0038
per 100 grams protein there is in				
...	0·058	1·694	1·078	0·0150
...	0·109	1·671	1·148	0·0055

mary :—

oods rich in Calcium are Milk, Egg-yolk, Cheese, Watercress, Oatmeal, Spinach, Almonds.

oods rich in Phosphorus are Liver, Kidney, Egg-yolk, Meat, Fish, Cheese, Oatmeal, Almonds.

oods rich in Iron are Liver, Meat, Egg-yolk, Peas, Spinach, Almonds, Raisins, Oatmeal.

oods rich in Iodine are Fish, Sea-kale, Cod Liver oil.

Foods— and Alkalies.

When food substances are completely dried and burnt away mineral ash alone remains. The food ash e acid, alkaline or neutral and the character ultimate incinerated minerals would appear

to have a considerable bearing upon the m
ance of health. Normally the body tissues and
are slightly alkaline in reaction. If there is any lo
of the alkalinity below a particular value the condi
" acidosis " results. This state may be readily b
about by an excessive diet of food rich in acid-fo
bodies, such as the higher proteins, which when
oxidised yield as by-products, sulphuric and phos
acids. Excess acid formation is also a feature of w
diseases as fevers, when the body tissues are being
sumed, and diabetes, when oxidation of carbohydrate
short of the ultimate carbon dioxide and water, a
stage of either β-hydroxy-butyric acid or diacetic
(see page 158). The symptoms of acidosis, however ca
are a general lack of muscular and nervous tone, failu
appetite and interest, headache and high blood pressu

Foods may be divided into two classes—the acid
foods and the alkaline ash foods—and be graded w
the classes in terms of the number of cc. of N/1NaO
N/1HCl required respectively to neutralise the ash of
grams of food. Thus :—

Acid Ash Foods :—

Oysters	30	Lean Beef	14	Oatmeal
Chicken	17	Eggs	11	Rice
Haddock	10	Egg yolk	27	Bread

Alkaline Ash Foods :—

Raisins	24	Carrots	11	Oranges
Currants (dried)	26	Beet	11	Lemons
		Potato	7	Bananas
Almonds	12	Lettuce	7	Apples
Dried Peas	7			
Cows' milk	$2\frac{1}{2}$			

A diet of only meat, fish and cereals, that is of s
stances giving acid residues on final oxidation in
body or in the crucible, is conducive to acidosis. On
contrary, such vegetable foods as roots, stalks, leav

bulbs and fruits when finally oxidised, leave residues. Although some plant structures are ly acid to taste, as lemons and rhubarb, when onsumed, they yield neutral or alkaline residues : idity is due to free organic acid, such as citric, oxalic acid, these burn to carbon dioxide and if it is due to acid salts of potassium and calcium, ld alkaline carbonates as residues. As a result of tabolic changes within the system, the acids from the oxidation of the proteins, and at times hydrates, are neutralised by the alkaline residues from the vegetable and fruit ingredients of the ese latter should be in sufficient excess to maintain ree of general tissue alkalinity which is essential h. The advantages of a diet of protein foods, animal or plant in origin, mixed with vegetable some variety, are largely explained by these facts. t only to supply the balancing carbohydrate, or e "roughage," that vegetables should be eaten eats : their ultimate mineral salts are no less nt. Here lies the justification of many common sitions of food stuffs ; as of beef and potatoes ; d apple sauce ; cheese with onions, celery or water- bread and jam ; bacon and marmalade ; and of almonds, raisins and fruit after a dinner of one meat dishes.

rtunately when vegetables are boiled in water, sap, with the dissolved salts, generally escapes from gulated cell protoplasm into the cooking water, if bulky, is often thrown away as useless. Even rom the matter of the vitamins, which may be or in part destroyed by this method of cooking, d value of the vegetables is appreciably lessened loss of salts. The cooking of vegetables should be as little water as possible, and preferably wherever by steaming, and the fluid collected and being valuable plant minerals should if convenient be r making gravies or stock. Potatoes are best in their skins, for these contain most of the mineral ee also page 314).

EXPERIMENTS ON MINERAL MATTER IN FOO

Experiment 1.

To determine the percentage of mineral ash in a food mate

Weigh a clean dry crucible. Add to it about 5 grams of material, e.g., grated cheese and weigh carefully. Heat the gently over a bunsen flame until most of the organic matter destroyed and then strongly in a muffle furnace for seven When nothing but a clean ash remains, cool in a desiccator a cold, weigh. Place in the muffle furnace for a further several hours, re-cool in a desiccator and re-weigh. Contin constant weight is obtained. From the weighings obtained the percentage of mineral ash in the food.

It is important to remember in these estimations that the age of mineral ash is low and that care is needed in weighin the first heating to prevent loss of material.

Experiment 2.

To identify the mineral constituents of foods.

Reduce the food material to ash as described in the p experiment. Note the colour of the ash. This is usuall but in the presence of iron salts a brown tinge may be not Dissolve the ash in about 20 ccs. of distilled water slightly a with nitric acid.

The common acid radicles in food are carbonate, chloride, su and phosphate. The common metallic constituents are s potassium, calcium, magnesium and iron.

Carry out the following tests on the solution of ash.

(a) Carbonate.

To about 3 ccs. of the solution add a few drops of dilute chloric acid. Effervescence will indicate the probable pres carbonate.

(b) Chloride.

To about 3 ccs. of the solution add a few drops of silver solution. A white precipitate of silver chloride will indica presence of chloride.

(c) Sulphate.

To about 3 ccs. of the solution add an equal bulk of 10 per barium chloride solution. A white precipitate of barium su insoluble in hydrochloric acid will indicate the presence of sul

(d) Phosphate.

To about 3 ccs. of the solution add 1 cc. of concentrated acid and 3 ccs. of 10 per cent. ammonium molybdate so Heat in a beaker of boiling water. The formation of a y colour or precipitate will indicate the presence of phosphate.

.

e test is most suitable. Dip a platinum wire into the some of the solid ash and heat in the Bunsen flame. A e colouration will indicate the presence of sodium.

um.

e test is most suitable and is carried out in the same way m. A lilac flame colouration will indicate the presence m. If sodium has already been identified the flame should ed through cobalt blue glass.

m.

monia to a portion of the solution until it is slightly nd then make it slightly acid with acetic acid. Add equal volume of 5 per cent. ammonium oxalate solution. tion of a white precipitate of calcium oxalate indicates ce of calcium.

sium.

cipitate has been formed in the previous test, remove it on and make the filtrate strongly alkaline with ammonia. of 10 per cent. sodium phosphate solution. The formation alline precipitate indicates the presence of magnesium.

Iron.

several cubic centimetres of the solution with hydro- id. Add about 1 cc. of 10 per cent. ammonium thio- The formation of a red colour indicate the presence of

CHAPTER X.

WATER.

Although water may not be strictly counted as
the sense that carbohydrates and fats are foo
which energy can be liberated, it is a food, as pro
food, in that it is an essential building materia
living tissue, and as minerals are foods, in that it
essential part in the processes of metabolism. C
life without water is impossible.

Some two-thirds of the weight of the human
due to water; mostly, some 50 per cent. in the m
13 per cent. in the skeleton, and 5 per cent. in the
The greater part occurs in the combined state, eith
loosely attached component of the colloidal p
which form the bulk of the muscular, nervous and c
tive tissues, or more firmly combined in carbohy
from which it is liberated within the system by
molecular breakdown. The remainder of the body
exists in the free state. It soaks all living tissues
are only active when turgid—and it provides the
basis of blood, lymph, glandular secretions and excr

Water is remarkable among liquids, both natura
artificial, in the catholicity of its solvent power
dissolves not only a great variety of inorganic substa
solids, liquids and gases—but also of organic compo
Nor is it a neutral medium acting simply as a so
for by its power of dissociating electrolytes—acids,
and salts—into their component ions, it plays a pr
role in making possible chemical interaction among
substances, as in double decomposition, precipitatio
the like. Water itself dissociates into the ions, hy
(H) and hydroxyl (OH), and as such can play an
part in certain chemical changes.

The most evident use of water in the body is as a c
of waste materials, chiefly nitrogenous, liberate
metabolism and discharged in the urine, perspiratio

s. Another plain use is seen in its evaporation
ir or its exudation as liquid, in the process of
ion, in these being always accompanied by
f the skin and the immediately underlying tissues
which blood is passing in large quantities. By
face cooling the temperature of the body, in the
health, is kept fairly constant despite exposure
ion to high solar or atmospheric temperatures or
in winter, or the liberation of large quantities of
hin the system during violent exercise or heavy
At rest, or under conditions of moderate tempera-
ne one and a half pints of water escape daily by
tion. During strenuous games when much
r heat is liberated, the rate of loss is much higher ;
the course of a game of football may amount to
8 and 10 pints per hour.

otal daily loss of water by way of excretion of all
mounts under average conditions to about 4½
To meet this loss and to maintain a balance
the various tissues, on the average 2½ pints of
must be imbibed daily ; the remainder being
otherwise, in part contained in the solid foods
lly eaten, and in part liberated within the body as
oduct of metabolism, as in the oxidation of fats
teins and in the disintegration of carbohydrates.
article of solid food contains some free water,
st particularly when cooked. Thus lentils contain
cent. of water, green peas 28 per cent., potatoes
ent., turnips 90 per cent., white bread 39 per cent.,
beef 71 per cent.

olic water is liberated as a result of oxidation
he tissues of proteins and fats, and of the break-
sugars. Thus 100 parts of fat yield 107 parts of
nd 100 parts of protein 41 parts of water, by the
n of their hydrogen ; 100 parts of a hexose sugar
60 parts of water of combination which is freed
oxidation of the carbon. This metabolic water it
lated accounts for about 16 per cent. of the water
from the body and would appear to be sufficient
the needs of many insects. The oxidation of

fats in the hump of the camel produces a useful s
water in the case of emergency, and in the case
which perspire but little, their diet of meat pro
fair proportion of the water they need.

The quantities of water to be imbibed under pa
circumstances, for health and comfort to be main
must depend very largely upon the nature o
conditions; as upon the temperature and humi
the atmosphere, the amount of clothing, the occ
followed, whether it is strenuous or easy, and so
these are intimately related to perspiration loss
also depends upon the nature of the food eaten, w
for example it contains, as is usual in cooked food
free water, and the amounts of food principles repre
With a bread diet, rich in carbohydrate, the fe
usually fluid and occasion an abnormal loss of wate
the system, which is usually corrected by drinking
quantities of water. Meat protein taken in
presently results in the excretion by the kidn
increased quantities of nitrogenous waste produc
calling for more water for their satisfactory elimin
The poisonous substances produced in the intesti
bacterial action on food materials, especially pr
also call for liberal quantities of free water for
removal from the system. Water here acts part
directly diluting and bodily removing the bacteria
fæces, and partly by ensuring the more ready exc
of the toxic substances through the usual orga
excretion—the kidneys, skin and intestines. This s
leaching, or washing out, of the poisons from the t
generally by ample supplies of water, is definitely indi
as called for in the treatment of such disorders a
common cold, rheumatism, gout, diabetes, nephriti
fevers.

Even under ordinary conditions of health, most p
in the course of an ordinary day's work could
advantage drink more water than the usual pint and
or two pints. The glass of hot or cold water at r
even more than the usual cup of tea, has much to re
mend it. Some persons find a night-cap of hot

. There also appears to be nothing against it, he contrary much in its favour, in the practice ng a fair amount of water during meals. Experi- shown that it is only when drunk in excess, say nts at a time, that it begins to show marked e action upon digestion. Certainly the glass of fore a meat meal stimulates the flow of saliva gastric juice besides toning up the stomach and m As pointed out elsewhere (page 143), even if in large quantities on occasion, water is not by the epithelium of the stomach. It begins to almost immediately through the pylorus into the m and continues to do so in small gushes. A cold water requires about three quarters of an pass but hot water passes more quickly, perhaps lt of the greater stimulating effect of heat upon ic movements of the stomach and the muscular the pylorus. The relative speedy discharge of om the stomach has certain disadvantages. If d water is drunk in quantities especially on an tomach, there is little chance for its temperature justed to that of the body before some of it passes intestines, and if infected before the hydrochloric he gastric juice will have had time to exercise its nicidal power.

r plays an important part in the digestion and nt of food in the alimentary canal. It is the in which are dissolved the several digestive s secreted in different glands in the mouth, and small intestines. It provides the fluid t of the food in its successive stages of digestion. ome is supplied directly to the alimentary canal thout either as drunk or as part of the food eaten, roportion of the water in the most fluid contents nall intestines is actually secreted into the digestive m various glands—perhaps as much as between nine pints daily. The greater part of this water of urces is usually absorbed into the system in the f the large intestine, i.e., the colon and rectum.

ould appear that within limits the taking in of

greater quantities of water or of less quantities t
customary is not accompanied, except over short
by any marked change in the total quantity
circulating fluid—blood and lymph—and in its co
tion. Evidently the body can adjust itself fairly
to either state of temporary excess or deficiency.
water intake is reduced by some 27 per cent., the
in concentration begin to be marked, affecting the
of the plasma, the proportion of solids in it, a
number of red corpuscles in unit volume, but ev
the change is only temporary, for presently the
conditions are restored by the influx into the blood
of free water from the tissues generally. A pro
shortage of water in the diet will eventually bring
the body weight materially, not by the wastage of
substance as muscle and fat but by its relative desic
The state of fever and of excessive perspiration cau
heavy physical exercise similarly reduce weight by
tissue water.

Normally, water drunk on an empty stomach or be
meals is wholly excreted in the urine in the cou
three hours. When it actually leaves the body li
because drier than before, is a result well marked
period between meals is one of vigorous physical oc
tion. Coal miners occupied in hard work for long p
in hot moist atmospheres naturally perspire conside
losing not only much water but also common salt.
consequent thirst is frequently slaked by drinking
although the water balance in the tissues is so maint
the case is not so with the saline matter, with the
that muscular cramps, and perhaps more serious
develop unless common salt is added to the drinking
or small pieces of rock salt are sucked and the
concentration so restored.

SECTION C.—ABSORPTION OF FOOD.

CHAPTER XI.

DIGESTION.

e of Digestion. Food in any meal comprises a fair proportion of substances that ry evidently insoluble in water, as well as beverages re almost wholly water, and such substances as acids, mineral salts, etc., which are soluble in the of beverages or of foodstuffs as prepared for the Food in eating enters the alimentary canal, which be conveniently considered to be a tube passing gh the body, and its cavity in a fashion as really nal to the system. Anything that is not in a state ution, or of fine emulsion, is unable to pass through all of the alimentary canal and so to enter the system. ood therefore to be made available as a whole to the s of the body, as a source of energy and repair ial, it must first be converted into such a physical hemical state that it can pass through the lining of limentary canal. This transformation is effected e process of digestion. This consists essentially of ing about a change in the chemical substance of the hydrates, proteins and fats, largely by the addition e elements of water—hydrolysis—under the action ecial digestive agents, the enzymes. The enzymes oured out into the cavity of the gut—in the mouth the salivary glands, in the stomach from the gastric s, in the duodenum from the pancreas, and in the intestine from dispersed glands. The digestive nes are specific in their action, and are distinguished ose that hydrolyse carbohydrates, those that hydro- roteins (proteolytic) and the flat splitting enzymes.

e soluble and simpler derivatives of food substances uced by the hydrolysing action of enzymes are in a state that they diffuse more or less freely through lining membrane—epithelium—of the alimentary

canal, mainly in the small intestine, and enter the cir
tory system by means of which they are quickly t
ported to the tissues for use as fuel or building mat
or to storage organs like the liver. The odd thing is
the breakdown products of enzymic digestion soon a
being assimilated into the system are in large mea
restored to their original grade by dehydration
condensation : thus, the amino-acids are integrated a
as proteins or polypeptides, the fatty acids are recomb
with glycerol as fats, and glucose is condensed as glyc
or animal starch. Digestion is simply a means of effec
the transfer of food substances across the thin epith
coating of the alimentary canal from the gut cavity i
the circulatory system.

Digestion of food is carried on in succession in sepa
parts of the alimentary canal—the mouth, stomach a
intestines—by several distinct and narrowly speciali
enzymes. In the mouth, the salivary glands secrete
active substance the enzyme ptyalin, which conve
starch into more soluble forms of carbohydrates.
the stomach the gastric glands secrete pepsin, which
the presence of hydrochloric acid converts proteins in
polypeptides and peptones. The pancreas secretes in
the duodenum, three distinct enzymes ; one, tryps
which converts proteins, polypeptides and peptones in
their ultimate amino-acids, a second, amylase, whi
changes polysaccharides like starch and disaccharides li
malt sugar into monosaccharides, chiefly glucose, and
third, lipase, which splits fats into their component fat
acids and glycerol. In the small intestine, supplementa
to the pancreatic enzymes, among other enzymes,
erepsin, an ingredient of the succus entericus ; this h
the power of converting polypeptides and peptones in
amino-acids, and a few proteins only (e.g., caseinoge
into amino-acids. The major process of digestio
continues in the small intestine, and here also takes pla
the greater amount of assimilation into the system of th
products of digestion. The final extraction of nutritiv
substances is effected in the large intestine, where als
most of the water of the fluid taken in with food
absorbed.

h briefly is the sequence of the processes of digestion, will now be considered in greater detail.

tion in the Mouth. The process of reducing the food to physical and chemical suitable for absorption is begun in the mouth. stication, when at all sufficiently practised, the teeth nd grind the pieces of food to a small size, and the e and mouth muscles generally, by their movement p the food with the saliva secreted by the salivary s. The very act of mastication stimulates the glands rete saliva, but the secretion of saliva is more of a action, in response to the stimulus of taste and to a extent of that of smell. Salivation is also closely d up with the emotions. The thought of food, cularly when one is ravenously hungry, is often gh to start it, and as Pavlov showed by his experi- s on the conditioned reflex in dogs, the note of the r bell may be sufficient. On the other hand fear stop secretion: a nervous orator suffers from dryness e throat, which calls for quick use of the water bottle, the old test by ordeal, when a suspected man was fed dry oatmeal which he could not swallow if dry- thed, is an example of the same feature.

he secretion of the salivary glands proceeds in the from three pairs of glands; the parotid, in front of ears, the sub-maxillary and the sub-lingual, respect- below the lower jaw and in the floor of the mouth. mixed secretion of the several glands consists mainly ater, made faintly alkaline with dissolved inorganic and slimy, because of a little mucin, and reactive to h because of the enzyme ptyalin. Saliva acts as a tener and lubricator of food, so as to admit of its passage down the gullet or œsophagus. Ptyalin has power of converting starch into maltose and dextrin, only when the cellulose covering of the starch is broken, as in fully cooked starch. In any case most people food is generally swallowed almost as as eaten, and ptyalin has practically no opportunity ffecting any chemical change in the mouth. The n of ptyalin however continues awhile in the stomach, it can proceed in the neutral or even slightly acid

medium, especially before the starchy food passes the cardiac end of the stomach into the pyloric where it is first brought into contact with hydroc acid. Ptyalin materially assists gastric digestio hydrolysing starch beyond the colloidal state, in it takes up pepsin and so diminishes its action. starch grains are cooked with fat, as in pastry, potatoes or batter, the digestive action of ptyal considerably hindered and indigestion may be experie

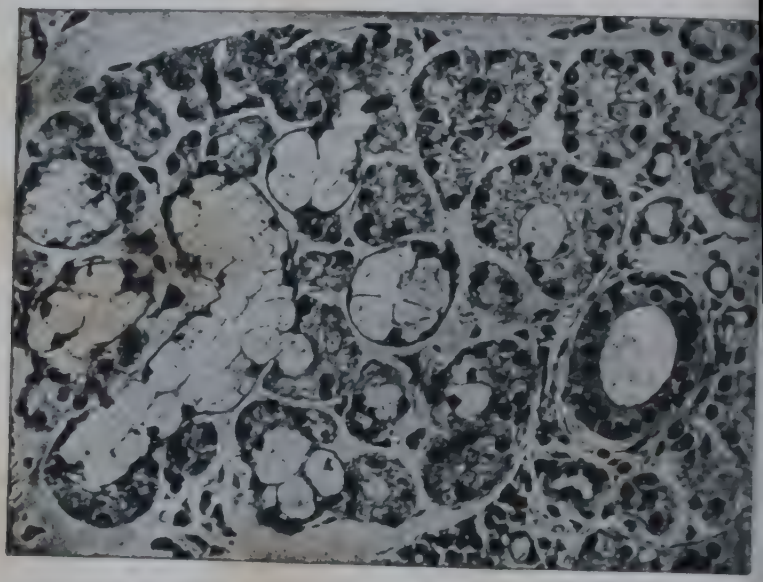
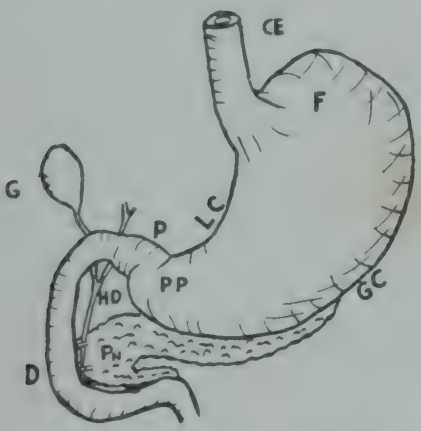


FIG. 27. Human sublingual gland (E. Sharpey-Schafer). Prep tion by M. Heidenhain x 200 photograph. Most of alveoli shown in the figure are serous, but some mixed containing chiefly mucous cells, but also a centric group of serous cells.

Digestion in the Stomach. The chief purpose of stomach, after all, is not a digestive organ—its functions as such are much bet performed by the small intestine—but as a reserv dealing out its contents in conveniently manageal quantities to the duodenum. Another useful function to bring foods of different temperatures all to the temper ture of the body, for which it is well adapted by

rdinarily rich supply of blood vessels. Hydro- acid acts as a powerful antiseptic ; a fact doubtless t importance in the case of the chance raw food savage, and not wholly without significance in the f civilised man.

urally a certain amount of digestion of proteins ds by the action of the pepsin of the gastric juice, would appear that its main purpose is to produce emi-digested substances as will excite in the next ding portion of the gut—the duodenum—the ion of further enzymes required for the fuller ion.



s. Diagram of the stomach and duodenum. D. duodenum, F. fundus of stomach. G. gall bladder. G.C. greater curvature of stomach. H. hepatic (bile) duct. L.C. lesser curvature of stomach. OE. oesophagus, P. pylorus. Pn. pancreas. P.P. pars pylorica.

psin, in association with hydrochloric acid, hydrolyses ins to peptones. It is doubtful whether in addition is a distinct milk curdling enzyme—rennin. Lipase, t splitting enzyme, may be present in small quantities ts action, if any, is negligible in extent. Digestion n the stomach depends for its efficiency upon the leteness of the admixture of the food proteins with astric juice and the quantity of the latter. Well cated meat offers loose fibres among which the n enters readily. White meat, as that of chicken ish, is more easily accessible to gastric juice than

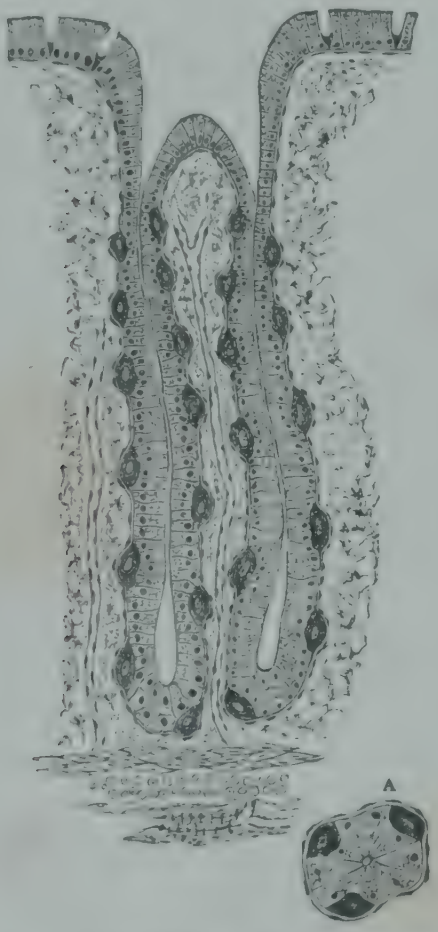
"coarse" red meat. Meats in which the muscle are mixed with fat are not readily attacked by pe and further, fat itself hinders the actual secreti gastric juice; hence the indigestibility of pork mackerel, and of fried goods generally.

The stimulation of the secretion of gastric juic preparation for the digestion of protein foods dep not only upon the chemical nature of the food prese to the stomach, but also upon other factors, both ph logical and psychological. The dextrin produced in incipient digestion of starch in the mouth, and the w in the saliva both excite the gastric glands, hence justification for the usual nibbling at a roll before ta soup. The very expectancy of a meal, excited by mem or more immediate signs of smell, sound or sight, may s the flow of gastric juice which the subsequent n continues: pepsin and acid are already secreted at cardiac end of the stomach before even the food reac the stomach. If, however, the mind is occupied clos with other matters, as in deep study, in worry or anx ance, the flow of gastric juice is on the contrary check or completely held up; the appetite may disappear, a the meal if eaten may as likely as not prove heavy digestion. The ritual considered appropriate to a meal in company, the provision of pleasing furnishings the table, the practice of light and happy conversati the accompaniment of tuneful music, are all psychologi aids to the enjoyment of food and its easy digesti Solitary meals, with a text book or a newspaper propp up before one, are not conducive to good digestion.

The chemical nature of the food plays an important pa in stimulating secretion of gastric juice. Meat extractiv as concentrated in several proprietary articles are mo powerful; ordinary soups act in the same manner, hen their place early in the ordinary dinner menu. A glass cold or hot water just before a meal besides serving wash out the stomach slightly stimulates gastric secretion milk and gelatin produce a similar reaction but eg albumin none, while fat definitely retards secretion.

continued secretion of gastric juice is maintained
stimulation of the glands at the cardiac end by
rmone gastrin, which is produced by the glands at
her or pyloric end, and transmitted in the blood
. Gastrin continues to stimulate as long as there
food in the stomach.

gastric flow as secreted contains about 0·4 to 0·5
nt. of hydrochloric acid: as mixed with food the



. A fundus gland (from Gray's "Anatomy") A. A transverse section through the gland. Note the deeply staining parietal (oxyntic) cells bordering the chief or zymogenic cells: the former secrete hydrochloric acid and the latter the gastric ferments.

percentage drops to 0·2 per cent., which would seem the optimum concentration for the action of the en As the neutralising substances are used up, the conc tion rises until about an hour-and-a-half after the In the resting period and after some alkaline co have passed back from the duodenum throug pylorus the concentration is as low as 0·03 per The intake of other food acids as in sour fruit chec secretion of the hydrochloric acid ; alkaline carbo by neutralisation lower the acid concentration qu but afterwards the acid secretion may be increased.

The movements of the stomach are of primary im ance for they ensure a complete mixture of its cont The stomach in the matter of its movements consis two parts (i) the fundus or pit half of the body o stomach which serves primarily as a store of food in w ptyalin digestion may continue for a while ; and (ii further half, the pyloric " churn " or " mill " where food is mixed up with the pepsin and acid and r fluid enough to pass through the pylorus into the denum. Peristaltic movements set up from the mi of the body separating these two halves, impel the " chyme " forward. In dogs the presence of free aci the pylorus would appear to be the chief factor in opening of the pyloric sphincter, but in man and mechanism, that of mechanical stimulus, would appea operate.

Both carbohydrates and proteins induce the gas secretion, but while proteins unite chemically with it satisfying it, carbohydrates do not. The digestion of proteins is assured before there is an excess of causing the muscles to relax but with carbohydr alone free acid is quickly evident. While a meal proteins and fats is retained in the stomach for long peri of three or four hours a meal of carbohydrates is rapi passed out. It is for this reason that persons with w stomachs are advised to take their proteins and car hydrates at separate meals, and those liable to excess a to take a fair amount of fat. The normal acidity of stomach causes the closing of the cardiac orifice where

us opens into the stomach; if there is any
y in acid the cardiac muscle ring is relaxed and
ially produced by fermentation when acidity is
upwards into the mouth, producing a coated
nd an unpleasant taste.

the primary function of the stomach is not
is evident from the fact that very little absorp-
es place in it; alcohol, sugar, albumin and
slightly, are, however, absorbed at the
nd. When the stomach is full, water passes into
enum going directly from the cardiac entrance to
rus along the lesser curvature of the stomach.
of coffee taken at the end of dinner, in effect,
ort circuits the stomach and passes almost
tely into the small intestine.

ARY. The main result of gastric digestion is
rolysis and solution of those parts of meat that
elatin, such as connective tissue, white fibrous
erve sheaths, muscles and glands and the enve-
fat cells: gluten of bread and the protoplasm
t cells are also hydrolysed. Starch is largely
ed into maltose, and cane sugar to a certain extent
ucose and fructose; cellulose is untouched and
nly scarcely affected. The caseinogen of milk
d as casein.

n in the testine. As soon as the acid chyme passes from the stomach through the pylorus into the duodenum the hydrochloric uses the mucous membrane of the duodenum to a hormone, secretin, which is then carried by d to the pancreas where it stimulates certain of to secrete pancreatic juice. Without secretin fore it hydrochloric acid, there is no flow of tic secretion. Secretin also stimulates the liver, bile appears in the duodenum at the same time as creatic juice.

ancreatic juice is alkaline in reaction and contains distinct ferments; (i) trypsin, acting on proteins,

(ii) amylase hydrolysing starches, (iii) lipase sp
fats, and (iv) a milk curdling enzyme. The pan
juice in its turn stimulates the secretion of the suc
tericus, or intestinal juice, further along the small int

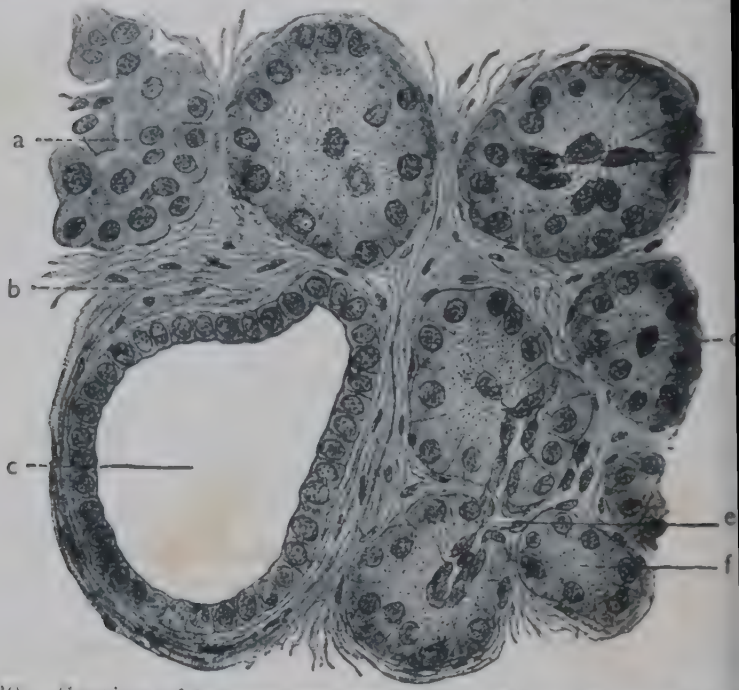


FIG. 30. Section of human pancreas (Bohn & v. Davidoff) x
a. part of an islet of Langerhans (producing insu
b. connective tissue; c. and e. ducts; d. and f. alv
cells which secrete pancreatic juice.

Trypsin breaks down proteins by progressive hydrol
through polypeptides until the final products the vari
amino-acids. It also completes what the gastric digest
has already begun on the proteins by splitting the p
tones and polypeptides still further to amino-acids.
succus entericus contains two proteolytic enzym
entero-kinase which liberates trypsin from trypsinog
and erepsin, which hydrolyses peptones, the products
gastric digestion, to amino-acids. Erepsin can act on
proteins only, such as caseinogen. Digestion does not
beyond this grade of compounds and from these,
building units, new proteins are presently synthesi

e system (see page 157). It is only as amino- nitrogenous food substances can diffuse through elium of the alimentary canal.

se, like ptyalin, acts on starch converting it into ar or maltose but differs from it in its more action and in being able to dissolve unboiled The succus entericus contains further ferments act with carbohydrates : viz., invertase converts ar into glucose and fructose, while a second, converts malt sugar left by the action of ptyalin lase into glucose, and a third, lactase, converts ar or lactose into glucose and galactose. In he power of digesting milk sugar is small, and ntly for them milk is valuable only for its and fats. No enzyme is secreted anywhere in entary canal which can split up cellulose, and except for that small fraction which is reduced ction of bacteria in the large intestine, meagre in son with what takes place in herbivora generally, is unattacked and passes through the body d. Foods that contain a good proportion of and lignin, such as "greens" of various sorts, icularly useful in maintaining the consistency of ls in the stomach and intestines, and in assisting staltic movements by presenting firm substance grip. Any residual lactose is acted upon in the by lactic bacteria which convert it into lactic t was suggested by Metchnikoff that lactic acid ntly abundant in the intestine inhibits the increase ria that are positively harmful, causing ill-health eed shortening life. He ascribed the longevity of arian peasantry to their heavy milk diet. Follow- view there was for a time a vogue in sour milk

e, the fat splitting enzyme of pancreatic juice, tivated by the salts of the bile, decomposes food fatty acids and glycerol. The bile as a strongly fluid reduces the surface tension of the nutritive the intestine, and so assists very materially in the cation of the fats, whereby an extraordinary

amount of surface relative to mass is presented
action of the enzyme. The glycerol dissolves read
the free fatty acids are so minutely emulsified th
pass easily through the membrane of the villi,
constitute the greater part of the inner surface
intestine, and so into the lacteals. The fatty acids re
from common fat foods are stearic acid, palmiti
and oleic acid ; of these oleic acid is the most
absorbed and stearic acid the least. As soon as t
components enter the villi they are recombined int
again ; these synthesised fats are not identical

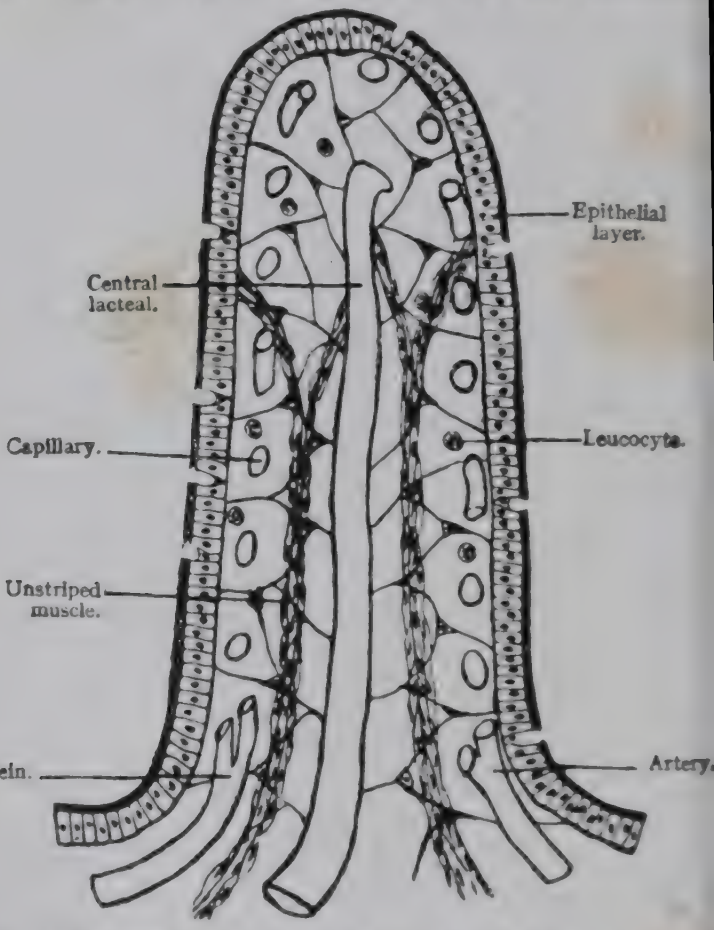


FIG. 31. Diagram of a villus (from Bainbridge and M
"Essentials of Physiology.")

nal food fats but are characteristic of the system ch they have been absorbed. It appears odd much requires to be done to food fats to split o their chemical components, only to recombine soon as they have passed into the epithelium the villi. Mineral hydrocarbons like paraffin line, even if emulsified either before being taken e mouth or naturally in the small intestine, are d upon by lipase nor are they absorbed by the Whatever their use may be when taken, as in proprietary articles, it is not as a food, for failing nto the system they are rejected from the alimen- nal unchanged and undiminished. At best their s to lubricate the passage of the fæces.

fats do not pass into the portal system and so into the liver as do the sugars and amino-acids spersed as microscopical globules, pass into the which finally converge into the thoracic duct e superior vena cava, and by it empty their s into the blood stream. It would appear that some advantage in the fats thus short-circuiting r.

on in the ntestine. Practically no digestion or absorption of food compounds proceeds in the large intestine ; its primary function the absorption of the abundance of water in the al contents and the final formation of the fæces. ces contain not only that fraction of the food which to remain after all possible digestion and absorption ve taken place, but also lipoid substances, e.g., erol, derived from the liver in the bile, epithelial ed off from the walls of the intestines, and as much third of the dry weight of bacteria—the vast y dead.

SUMMARY OF DIGESTION.

Carbohydrates.

outh—Ptyalin in alkaline media converts starch lt sugar (maltose) and dextrin.

$$(C_6H_{10}O_5) + H_2O \longrightarrow C_{12}H_{22}O_{11}$$

In Stomach.—Ptyalin in neutral and slightly acid continues the conversion of starch into malto dextrin.

In Small Intestine—Pancreatic juice containing

Amylase—converts starch into maltose and

Succus entericus containing :—

Maltase converts maltose into glucose.

Lactase converts lactose into glucose galactose.

Invertase converts cane sugar (sucrose) into g and fructose.

$$C_{12}H_{22}O_{11} + 2H_2O \rightarrow C_6H_{12}O_6 + C_6H_{12}O_6$$

B. Of Proteins.

In Stomach—Gastric juice containing :—

Pepsin in acid (HCl) medium converts pr into peptones and polypeptides.

In Small Intestine—Pancreatic juice containing :—

Trypsin in alkaline medium converts protein polypeptides and amino-acids.

Succus entericus containing :—

Erepsin in alkaline medium converts peptone certain proteins into amino-acids.

C. Of Fats.

In Stomach—Little action.

In Small Intestine—Pancreatic juice containing :—

Lipase in alkaline medium converts fats glycerol and fatty acids.

EXPERIMENTS ON ENZYMES.

Experiment 1.

To investigate the action of diastase on starch.

(*a*) **The influence of temperature.**

For this experiment use 1 per cent. starch paste and 1 per diastase solution. Into each of a series of eleven test-tubes intr 20 ccs. of the starch paste and 10 ccs. of the diastase solution. the two liquids together by a thorough shaking and then

tubes to each of the following temperatures 0°C., 10°C. C., 40 C., 50 C., 60 C., 70 C., 80 C., 90 C. and 100°C. all the experiments as nearly as possible at once. At ning of the experiment and every 10 minutes afterwards drops of the liquid from each tube and test its reaction with f 1 per cent. iodine solution which has previously been idified. Reserve the tubes in each case for purposes of n. Note the order in which no colour is given with the ution and conclude as to the relative rates of hydrolysis of by the diastase. When the starch has been hydrolysed, presence of a sugar by Fehling's solution or Barfoed's test pt to identify it by the preparation of an osazone.

sults should be similar to the following :—

ure.	*Colouration with iodine solution.*
C.	Blue colouration—no change.
C.	Blue colouration—no change.
°C.	Blue colouration changes slowly to purple and then brown.
C.	Blue colouration changes more quickly to purple and then brown.
C.	Blue colouration changes more quickly still to purple, then brown and finally colourless.
°C.	Same as at 40 C. but more slowly.
C.	Blue colouration changes to purple.
C.	Blue colouration changes to purple very slowly.
C.	Blue colouration remains unchanged.
C.	Blue colouration remains unchanged.
°C.	Blue colouration remains unchanged.

bring the test-tubes which have been at 0°C., and 10°C., C. and 90 C., and 100 C. to 40 C., for a short time and test th iodine. The results you obtain should indicate that at peratures the activity of the diastase is inhibited but the is not destroyed. At high temperatures, e.g., 100°C., the is destroyed.

imum temperature for diastase activity 70°C.

imum temperature for diastase activity 20°C.

imum temperature for diastase activity 40 C.

the application of these facts to the preservation of food s by refrigeration and sterilisation.

ence of the medium.

the previous experiment work with 1 per cent. starch paste, nt. diastase solution and 1 per cent. iodine solution slightly . Into a series of five test-tubes introduce 20 ccs. of the aste and 10 ccs. of the diastase solution. Mix the two liquids

together by a thorough shaking. Treat each test-tube se
as follows :—

(*a*) Keep neutral (N
(*b*) Add 4 drops of concentrated hydrochloric acid.
(*c*) Add 4 drops of concentrated caustic potash. (A
(*d*) Add 4 drops of saturated sodium chloride solution
(Neutr
(*e*) Add 4 drops of saturated sodium carbonate solution
(Alkali

Heat all five test-tubes to 40°C. (temperature of ma
activity of diastase) and test every ten minutes with iodine s
as in the previous experiment.

N.B.—Neutralise the test samples before the addition of
where necessary.

From your results you should be able to conclude as to the
on the rate of activity of diastase in media of different ty
follows :—

Medium.	*Influence.*
(*a*) Neutral solution.	Favours enzyme acti
(*b*) Neutral salt solution (trace).	Favours enzyme ac (when dilute).
(*c*) Alkaline salt solution (trace).	Inhibits enzyme actio
(*d*) Alkaline solution	Checks enzyme action
(*e*) Acid solution.	Checks enzyme action

(*c*) **The influence of concentration of any substance.**

As in previous experiments use 1 per cent. starch paste,
cent. diastase solution and 1 per cent. iodine solution sl
acidified. Use a saturated solution of sodium chloride a
additional substance.

Introduce into a series of three test-tubes, 10 ccs. of the dia
and 5 ccs. of the diastase solution. Mix the two liquids togethe
thorough shaking.

Treat each test-tube as follows :—

(*a*) Two drops of saturated sodium chloride solution.
(*b*) 5 ccs. of saturated sodium chloride solution.
(*c*) 10 ccs. of saturated sodium chloride solution.

Heat each tube at the optimum temperature for diastase act
(40°C.) and compare the rates of activity of the diastase by te
samples with iodine as in the previous experiments.

Draw conclusions from your results as to the use of salt i
preservation of meat and the preservation of peels, crysta
fruits, jams and jellies by sugar.

nfluence of preservatives.

ice 20 ccs. of the starch paste into a test-tube together s. of the diastase solution and a few drops of a preservative alin. Heat for a short time to 40° C. and test with iodine or diastase activity.

lo as to the effect of chemical preservatives upon enzyme nd its bearing upon the preservation of foods.

nfluence of the absence of moisture.

gether solid powdered starch and solid diastase. Allow at 40° C. for several days. At the end of this time boil a he mixture with water, cool and test with iodine for starch Fehling's solution or Barfoed's solution for sugar.

your results conclude as to the activity of enzymes in the and the preservation of such foods as lentils, peas, beans, pricots, etc., by drying.

onclusions.

as hindering enzyme action.

Temperatures above 70°C. or below 20°C.
Unfavourable reactions of medium.
Concentration of any substance.
Presence of chemical preservatives.
Absence of moisture.

Experiment 2.

strate the actions of various types of digestive enzymes.

h splitting enzymes.

Ptyalin in saliva (Salivary amylase).

) ccs. of 1 per cent. starch paste with about 5 ccs. of saliva aporating basin and heat on a water bath at 38°C. (blood r about 20 minutes. Test with slightly acidified iodine (saliva is alkaline) and with Fehling's solution or Barfoed's If a sugar is found to be present, identify it by means of ne.

Pancreatic juice (pancreatic amylase)—amylopsin.

t as for the previous experiment using 2 ccs. of pancreatic made slightly alkaline with sodium carbonate solution. reason for this.

Splitting Enzymes.

creatic juice (pancreatic lipase) -steapsin

e a 1 per cent. solution of pancreatic extract in water and w drops of neutral olive oil. Make the mixture slightly with sodium carbonate solution. Heat to 38° C. (blood heat) al hours on a water-bath with frequent shaking. Note the

appearance of the liquid after several hours and compare th
of shaking the mixture before the experiment with the effe
the experiment.

(*c*) **Protein splitting Enzymes.**

(i) **Gastric juice (gastric protease)**—pepsin.

Acidify slightly a solution of pepsin with a few drops o
dilute hydrochloric acid. Add a small piece of boiled egg-w
of lightly cooked meat. Heat to 38°C. on a water bath for
hours. At the end of this time test the solution for protein
biuret test. Conclude from the colour produced whether a
or a complex protein is present.

(ii) **Pancreatic juice (pancreatic protease)**—trypsin.

Repeat as in the previous experiment, using a solution of pan
extract made slightly alkaline with sodium carbonate s
instead of pepsin solution.

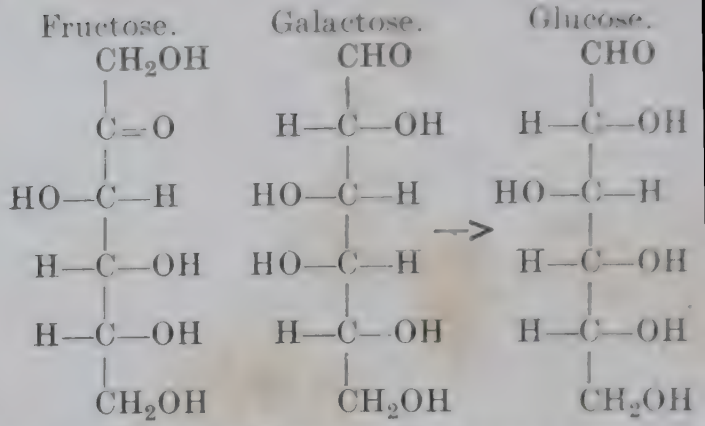
CHAPTER XII.

ASSIMILATION AND METABOLISM.

milation and bolism of ohydrates.

Carbohydrates can only be absorbed into the system in the form of monosaccharides and consequently all the different food polysaccharides, as starch, n and gums, and the disaccharides as cane sugar, sugar and milk sugar must first be converted by opriate enzymes of the digestive tract into the osaccharides, i.e., glucose, fructose or galactose. fully hydrolysed hexose, chiefly glucose, passes into capillaries of the villi of the small intestine and so ently by the portal system into the liver. If a ccharide like cane sugar is eaten in great excess, some may find a way into the blood as such without rolysis, but it is treated by the system as if it were a gn body and is excreted in the urine as quickly as ible.

hen glucose is not immediately required in the tissues converted in storage carbohydrate as animal starch ycogen by the process of condensation which is in all ihood effected by a specific enzyme. The liver and muscles generally store glycogen from the glucose in blood stream where it is maintained in health at a t corresponding to a concentration of about 0·1 per . The liver has a further function of converting the r hexoses, fructose and galactose, into glucose. In instances a re-arrangement of atoms within the ecule is effected.



When the liver is diseased, its power of conve fructose into glucose and so of removing it from the is diminished and the general health suffers. In circumstances honey or glucose sugar should be substit for cane sugar as a sweetening agent and artichokes are rich in inulin, yielding on hydrolysis fructose should not be eaten.

The change from a polysaccharide or disaccharide monosaccharide in hydrolysis and the reverse chan condensation are essentially the transfer of the elemen water (H_2O) by addition or by abstraction. But wh so often occurs in the system and apparently with readiness, fat is produced as a storage substance either glycogen or glucose, the process is one of lo oxygen or reduction and the change in the reverse dire of fat to carbohydrate is one of oxidation. The proce converting the comparatively simple molecules of a h sugar $C_6H_{12}O_6$, into th fat complex which consists compound of glycerol, $C_3H_8O_3$, with a long chain acid like stearic acid $C_{17}H_{35}COOH$, must be radic character (see page 67).

Glucose. Tri-stearin.

$$C_6H_{12}O_6 \longrightarrow C_3H_5(C_{17}H_{35}COO)_3$$

It may be observed from the formulæ that while i carbohydrates—glucose or glycerol—the hydrogen be regarded as already fully oxidised and the carbon free to combine with oxygen to form carbon dioxide

te energy, in the fats by far the greater portions of rbon and hydrogen both need oxygen from without eir combustion which is further accompanied by the r evolution of heat, mass for mass. As a matter of imental determination it is found that one gram of a hydrate yields on burning 4·1 Calories of heat and ram of fat 9·3 Calories. The conversion therefore n the body of carbohydrates into fat can only be d through by a process of absorption and storage of y ; the reverse change of fat to carbohydrate liberates nparatively large amount of energy over and above which is liberated when the carbohydrate is finally sed to carbon dioxide and water.

ycogen is now generally regarded as a source of y more immediately available in muscular opera- . It is derived, as we have seen, through the blood se from the food carbohydrates and also from the fat which in its turn is derived from food fats or less tly by reduction from food carbohydrates. In the se of the breakdown metabolic processes—catabolism e carbohydrate is fully oxidised in the tissues to give on dioxide and water and 4·1 Calories of heat for y gram. Carbohydrates in general are the most enient source of energy and are pre-eminently fuel s unless energy is required to be expended in work or eat at much higher rates than usual. Under such mstances carbohydrates are more or less replaced by with well over double the energy content. A heavy of bread or potatoes may serve for the maintenance of nergy output of the average manual labourer, but a y or other labourer engaged on very strenuous ical work would find it inadequate and be compelled pplement it with fatty foods such as bacon. Life in regions or at high altitudes is supported only on rich in fats.

combustion of the muscle carbohydrate and the liberation energy is not a simple process of combining glycogen with n supplied by the blood and the production of waste carbon e and water. The muscle is not simply a heat engine taking l and oxygen and giving out energy and waste products—the

former to be used in doing work and to be finally dissipated
and the latter to be removed by the blood stream. The lib
of heat as a result of the changes that take place in the mus
two stages. When the muscles contract doing work a por
heat is given out which is distinguished as the "initial hea
certain substances, lactic acid chiefly, are formed in the co
chemical processes carried out in the absence of free oxyg
further and equal quantity of heat is set free during the subs
recovery processes, presumably in the removal by oxidation
lactic acid liberated during contraction. That the liberation
during and after muscular activity was in two distinct stag
observed by Joule as early as 1844 but the exact nature
process was discovered only recently. During violent an
sustained athletic exercises the blood stream cannot supp
muscles rapidly enough with oxygen for the immediate and co
combustion of the lactic acid liberated in the first non-oxi
stage of muscular contraction. Under ordinary circumstan
exercise there is ample leisure for its removal. It has been
mentally determined that in the case of a single twitch of a
weighing about 0·1 gram, 0·0002 Calorie is liberated durin
15 minutes following contraction.

The efficiency of the muscle acting as a chemical engine
both periods of breakdown and recovery in terms of the
work done, to energy set free under actual working condition,
case of man is about 25 per cent. ; a value which is much highe
that of the average modern steam locomotive, although muc
than that of the high temperature petrol or oil engine.

While the main function of carbohydrate is to sup
ready form of energy it plays a subordinate but
important part in most other if not all of the meta
processes. Thus it spares the breakdown of tissues d
protein starvation. On a spare carbohydrate diet
excretion of urea, a measure of nitrogen metabolis
reduced considerably below the normal. Again
urea forms 80 per cent. of the total nitrogen excrete
the usual mixed diet, it is only 40 per cent. of the
when the diet is one predominantly of carbohydrates
diet devoid of carbohydrate results in the disorde
acidosis ; a state in which fats fail to be completely b
to the usual end products—carbon dioxide and wat
and intermediate acid products are formed instead
page 158). This dangerous condition can often
quickly removed by adding only a small quantity of s
to the diet.

nilation and bolism of

The glycerol and fatty acids digested from the food fats by the enzyme lipase are, as we have seen, resynthesised into a fat as soon as they the epithelium of the coating of the intestines. The e and fate of the fat after finally reaching the blood m by way of the lacteals and thoracic duct are not fully known. Some of the fat quickly reaches the l fat stores in the omentum and sub-cutaneous tissue perhaps some may be used almost immediately as almost certainly after being first converted into se or glycogen. But not all the fat that occurs in body is derived ultimately from food fats, for a varying unt is synthesised, as we have seen, from carbohydrates ell as from proteins after their de-aminization. There persons who readily form adipose tissue even though diet is carefully kept low in fats or even carbo-rates just as there are others of another type who ite a diet moderately rich in fats remain lean.

e metabolism of fats is closely related to that of carbohydrates. most serious result of a deficiency of carbohydrate metabolism e incomplete oxidation of the fats, for as it may be succinctly essed, "fats burn in the fire of carbohydrates." Dakin showed the fatty acid chain of fats is for the most part oxidised to on dioxide and water by the process of "Beta-oxidation" h consists in the oxidation of the carbon atoms two at a time the reduction to a lower member of the fatty acid series. For mple caproic acid $C_5H_{11}COOH$ becomes butyric acid C_3H_7COOH ss of carbon dioxide (CO_2) in this fashion :—

Caproic acid ——> Butyric acid

$$\underset{\beta\quad\alpha}{CH_2.CH_2.CH_2.CH_2.COOH} + 3O_2 = CH_3.CH_2.CH_2.COOH + 2CO_2 + 2H_2O.$$

breakdown in the chain taking place in the carbon atom in the position relative to the carboxyl (COOH) group. Butyric acid turn normally breaks down to acetic acid :—

Butyric acid ——> Acetic acid

$$\underset{\beta\quad\alpha}{CH_2\ CH_2.COOH} + 3O_2 = CH_3.COOH + 2CO_2 + H_2O.$$

etic acid finally oxidises to carbon dioxide and water.

$$H_3COOH + 2O_2 = 2CO_2 + 2H_2O.$$

At each of these steps of progressive oxidation of a long fatty acids such as those forming the basis of the food fats stearin and palmitin—heat energy is liberated.

In this progressive degradation of the fatty acid oxidation be peculiarly difficult at the butyric acid stage. Acids are exere the urine, if from a deficient carbohydrate metabolism combu is incomplete, instead of the usual carbon dioxide and water formed and oxidation stops at an early stage. Such interme products are β hydroxy-butyric acid ($CH_3CHOH.CH_2.COOH$) aceto-acetic acid ($CH_3.CO.CH_2.COOH$) :—

$$CH_3.CH_2.CH_2.COOH + O = \underset{\beta \text{ hydroxy butyric acid}}{CH_3.CHOH.CH_2.COOH}$$

$$CH_3.CH_2.CH_2.COOH + O_2 = \underset{\text{aceto-acetic acid.}}{CH_3.CO.CH_2.COOH}.$$

These acids tend to lower the alkalinity of the blood an power of combining with carbon dioxide (CO_2) and so set u disorder of acidosis or as it is also termed "ketosis." These substances are in themselves toxic and if the state is untreated death. When, as in diabetes, the primary cause is the failu the pancreas to generate insulin, the common corrective treat is to administer insulin to the patient.

Assimilation and Metabolism of Proteins.

Although proteins on the ave yield when burnt in a calorim 5·6 Calories per gram and in the b where combustion is incomplete, Calories per gram, that is as much as carbohydrates, t are not primarily fuels, even though they may be wa fully used as such when the diet is over rich in th Their proper purpose is to provide building material the growth and development of tissues and organs in organism, and generally also for the repair of wastage that continually goes on throughout all liv tissues. The fundamental substance of living cells much of the substance of the material formed by t ctivities in bone, cartilage, connective tissue, bl alasma, mucus and so on, are protein in nature, tho piffering widely in detailed composition. The b depends wholly for its protein material on the prot ingested as food and digested by the several proteol enzymes. Digestion consists essentially in the disinte tion of the different proteins of various foodstuffs into t ultimate polypeptides and amino-acids—soluble substa

nparatively small molecular mass which can pass
gh the epithelium of the intestines into blood
aries that are gathered up into the portal vein
passes into the liver. Blood continues to carry
mino-acids in good quantity beyond the liver through
cart and so throughout the systemic circulation
ally and thereby to every organ, tissue and ultimate
the body. The different tissues abstract from the
stream the particular amino-acids they need to build
eir substances, whether for the purpose of the repair
stage by usage or of growth and development, and
n the case of the various secretory glands of the
ration of their specific secretions, enzymes, hormones,
on. The re-assembling of the amino-acids presented
e system by the breakdown of the food proteins
s in the synthesis of new proteins characteristic of
nimal so maintained, and in detail of each of its
ate cells, tissues and organs. Out of the twenty or
mino-acids into which all proteins may be resolved
hus re-constituted a vast number of different animal
ins.

minization. Such amino-acids as are immediately required in kind and in quantity to up old and new tissues are taken out of the blood m and the remainder, usually the greater bulk, are nately decomposed being in part oxidised, so yielding gy. The removal of the amino group (NH_2) takes chiefly in the liver in the process of de-aminization e formation of ammonia (NH_3) or ammonium (NH_4) pounds. The remainders of the amino-acids become able as straight chain fatty acids or ring compounds arious kinds and serve as fuel. The nitrogen-free ues may under special circumstances even appear as gar. The ammonia is combined with one or other of commonly available waste products of oxidation to intermediate compounds which may be very poison- but these are normally converted in the liver to more or less harmless urea ($NH_2CO.NH_2$) to be y excreted from the system by the kidneys. If g to acute liver disease this function of the organ is

disturbed, ammonium salts may be excreted at the ex
of urea. Ammonia also acts as a neutraliser of abn
quantities of acids when these are formed in excess
diabetes. It seems very probable that such ammoni
not come immediately from proteins but is formed
kidneys from amino bodies at the expense of urea.

Protein breakdown. The metabolism of that po
of the amino-acids which is fu
elaborated into the tissue proteins and is after
broken down follows somewhat different lines.
breakdown of tissue proteins is continually proce
and on special occasions, such as during starvation,
other sources of energy are lacking, may be accentu
While the metabolism of the unattached amino-a
which form the bulk of the digested proteins, is cl
dependent upon the diet at the time, the metaboli
the proteins that have been built up into tissues is b
up with the general state of the system and is more st
in its course and uniform in its derivatives. This
metabolism, that of wastage of muscle, etc., is particu
evident during times of strenuous exercise, of fever a
starvation. Both kinds of breakdown of protein subst
give urea and sulphur compounds derived from
amino-acid, cystine. When the cystine has come
immediately from the diet, it has passed by the p
vein into the liver and been there oxidised in pa
inorganic sulphates, but when the amino-acid has
built up into a protein and afterwards liberated by t
breakdown it is not fully oxidised but is represente
the urine by a neutral sulphur derivative. And
characteristic product of tissue metabolism is creati
which is excreted in constant amounts unaffected by

When the diet is particularly rich in the proteins of the la
category—the conjugated proteins—among which the n
proteins are the most important, the end product of nitrog
metabolism is not urea as with ordinary proteins but uric
($C_5H_4O_3N_4$). Nucleo-proteins largely constitute the nuclei of a
cells and are therefore abundant in glandular structures, su
liver, kidney pancreas, reproductive glands and endocrine gla
thyroid, thymus, etc. Such of the richer and more tasty foo
this group are consequently contra-indicated for persons hal

r rheumatism, which are related to excess uric acid. Caffeine, nulant in tea and coffee, and theobromine in cocoa, are both related in molecular framework to uric acid.

Uric Acid.	Caffeine.	Theobromine.
$C_5H_4O_3N_4$	$C_5H(CH_3)_3O_2N_4$	$C_5H_2(CH_3)_2O_2{}_4$

periments on the details of protein assimilation show there is a decided time-lag between an increase in ntake of nitrogenous food and an increase in the t of waste nitrogen in the urine. This signifies somewhere in the chain of processes there must be sion for storage, in part probably as amino-acids n part also of material more complex than amino-acids.

rtance of o-acids od.

It has already been emphasised that the amino-acids are the basic units or "building stones" out of which the various proteins are conjugated and to n they are reduced as "produce" by suitable uctive hydrolysis. Considered in their physiological ons and as foods, the various proteins differ among selves in terms of the amino-acids and of their ortions which make up their composition. It is l by experiment that certain amino-acids are absolutely tial to life, being the basic ingredients of the more licated proteins of cell protoplasm; among these ryptophane and tyrosine. Only protein foods that ain either of these can support life. Food with dant proteins but these yielding no tryptophane can repair the wear and tear of tissues and so arrest ressive emaciation or prevent ultimate death. Other o-acids scarcely less indispensable are leucine, lysine, ne, and histidine. Some of these are required only inimal quantities which when supplied as such and out with good quantities of non-essential amino-acids make up the full quantity and variety of amino-acids. sine is considered necessary for the formation of the mones, adrenaline and thyroxine, without which rmal general metabolism is impossible. Certain other o-acids as lysine are necessary for the growth and lopment of young animals; adults can manage to ir their wastage of tissue in the absence of these growth

noting amino-acids.

Categories of Food Proteins. With these and similar considera in mind food proteins have been veniently classed in three categ i. Perfect ; ii. Imperfect ; iii. Deficient.

i. Perfect food proteins contain all or most of the a acids in sufficient quantities and proportions so growth continues and tissue is maintained. Good exa of perfect proteins are the flesh of animals, which co ample tryptophane and tyrosine to build up the nu proteins afresh.

ii. Imperfect food proteins disclose a deficiency but an absolute lack of the amino-acids essential to life. deficiency may be made up either by a diet providi large bulk of the imperfect proteins or even by o ordinary quantity but containing two or three impe proteins, as if the deficiency of one can be adjusted b deficiency of another. Examples of such deficient pro are gliadin of wheat and casein of cheese or milk.

iii. Deficient food proteins where there is a decided or complete absence of an essential amino-acid suc tryptophane, in no matter how large an amount take as food will fail to maintain life. Gelatin devoi tryptophane and practically also of tryosine is su food ; an animal fed on it alone is certain to di starvation.

Percentage Composition of some proteins in respect of ce Amino-Acids.

	Zein	Gliadin.	Gelatin.	Casein.	Milk Albumin.	M
Glycine ...	0	0	25·5	0·5	0·4	
Alanine ...	13·3	2·0	8·7	1·9	2·4	
Leucine ...	19·6	6·6	7·1	9·7	14·0	1
Glutamic Acid	26·2	42·7	5·8	2·8	12·9	1
Tyrosine ...	3·6	3·5	0·01	6·5	1·9	
Histidine ...	0·8	3·4	0·9	2·8	2·6	
Lysine ...	0	0·9	5·9	7·6	9·9	
Tryptophane ...	0	1·1	0	2·2	0	

Zein, the chief protein in maize, will not by itself support li all ; it is poor in histidine and totally lacking in both lysine tryptophane. If there is added to a diet of zein, food conta tryptophane, life is maintained but no growth takes place.

s added further growth is possible and life can be fully main-
Edestin from hemp proves capable of maintaining a growing
n health for most of its life but at long length it proves to
tequate, for after a period of normal health there develops
ly a premature ageing ending inevitably in death. If a
diet of mixed proteins is given at the crisis, the normal
is followed. A diet of hydrolysed casein alone, devoid of
phane, results in emaciation and death ; apparently the indole
nnot be synthesised in the body. The lack of the amino-acids
ic acid and aspartic acid does not produce such an effect, for
ould appear to be capable of being synthesised in the body.
ne also can be dispensed with, for gelatin which is devoid of it
stain life if tryptophane is added. The absence of both
ne and arginine results in loss in weight but not if either is
t. Evidently they are interchangeable. Gliadin, which
largely in wheat kernels, while maintaining a grown animal in
fails to ensure growth in a young animal. Fully grown rats
it continued alive and healthy, being also capable of reproduc-
Young suckling rats which had hitherto grown rapidly when
l from their mother and kept on gliadin at once ceased to
It would appear that the adult rat can form some substance
gliadin which the young cannot. If a half grown rat is fed
liadin as its sole protein it will only maintain its weight ; it
grow, remaining juvenile so long as gliadin alone is provided
other proteins are added growth is resumed and continues
he normal full size is attained, even if this means that the
of the usual growth period has been long past. Usually the
ng period of a rat is 180 days. In one experiment a young
lf grown at 37 days was halted at that stage on a diet of
for 271 days before being fed with mixed proteins when
was renewed and a full length of the growth period completed.
Peter Pan amongst rats kept on gliadin looked as old as its
nd not as old as its days. This suggests one possible mode of
ening life, by the interpolation of a standstill stage in
cence ! So far it has been found that under circumstances of
ry life the simple addition of extra quantities of either the
h promoting vitamin A or proteins rich in the indispensable
-acids does not result in any increase in growth beyond the
l. The taking of exercise, and especially the training of the
e, certainly results in the definite increase in the bulk of muscle
l as in its mechanical efficiency.

single protein of cereals — wheat, oats, rice, maize and so on —
fect and competent alone to sustain growth and health ; they
ck one or other of the indispensable amino-acids. When
they have it is true a much higher biological value than when
, but even then they have not enough lysine and cystine, and in
ases also not enough tryptophane. Nuts promote growth and
opment in animals as well as fertility and power of rearing their
. Maize when mixed with shredded coconut is fully adequate
ood.

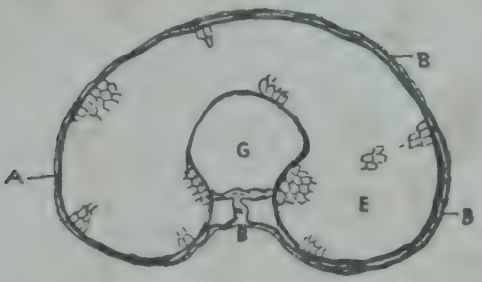
SECTION D.—COMMON FOOD MATERIALS.

CHAPTER XIII

CEREALS.

Wheat and Flour. Wheat is the most importa the cereals which include such portant food supplying plants as wheat, oats, barley maize and rice. Like the other cereals, wheat is a gra ceous plant or cultivated grass. It can be cultiv throughout the temperate regions, which constitute greatest land area of the world and include the civilised countries. The wheat plant grows best in a loamy soil, and the climatic conditions most suitabl its successful cultivation are moderate rainfall, s severe winters and dry hot summers, such as occu Hungary, Russia and North America. Wheats ca divided into two main types—Winter and Spring whe and are of three distinct colours, white, red and yel Winter wheat is sown in the winter time and spring w in early spring; the type grown in a particular dis depending, of course, upon the climatic conditi England with its mild winters and short summers g winter wheat, while in America it is possible to grow types of wheat. The type of wheat and the clim conditions under which it is grown have an impor bearing upon the quality of the wheat. Winter wh with the longer growing period produce a "soft" flou good flavour but with low protein content yielding s loaves. Spring wheats with the shorter growing pe give a "strong" flour of a harsh flavour with protein content and produce large well developed loa It is because of these differences that flours from diffe types of wheat are so frequently blended to give a pro suitable for the particular purpose for which it is inten thus a modern flour may be a mixture derived f wheats from almost any of the principal wheat grow countries of the world:—Europe, United States of Amer

a, Asia, Argentina, Africa and Australia. At a estimate we in this country grow about one-fifth wheat we require. Canada, Australia, India and parts of the British Empire supply about two-fifths needs and the remaining two-fifths come from e, Argentina and U.S.A.



2. Cross section of a Wheat grain. A. Aleurone grain layer. B. bran. E. endosperm G. groove or crease.

ture of the t grain.

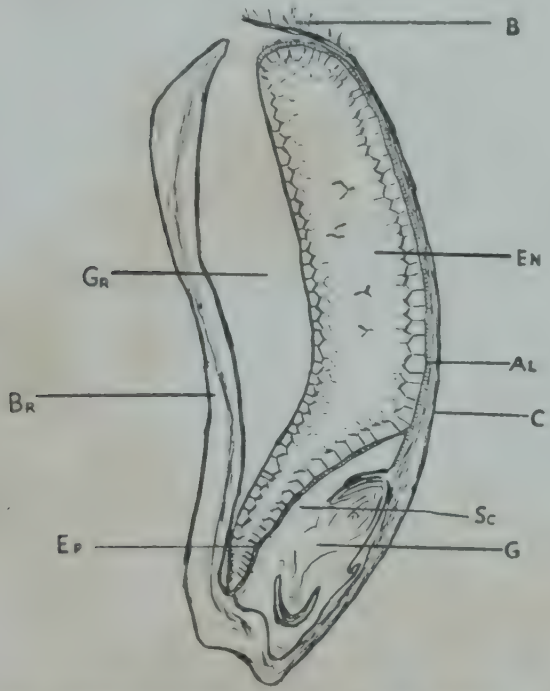
A spike of ripe wheat consists of a stalk to which the wheat grains or berries are attached and each grain is ed by a protective yellow leaf or glume. When the t is threshed the grain is separated from the stalk glumes which form straw and chaff respectively. berries themselves are roughly barrel-shaped and are pointed at one end than the other. At the pointed s a small tuft of hairs known as the beard and at the end which was originally attached to the stalk of heat plant is a small rough protuberance. This is erm embryo—the living part of the grain from which ermination the seedling develops. On the opposite s a deep furrow which passes along the whole length grain. It is here that dust and bacteria are liable llect and prove a source of trouble to the miller in eaning of the wheat before milling.

e wheat grain is the fruit of the plant. Fruits in al contain a seed or seeds surrounded by a protective ing known as the seed coat or testa and the whole

contained in an outer coat or pericarp formed from
wall of the ovary. The fruit of the wheat plant co
of a single seed with both seed coat and fruit wall—
and pericarp closely attached to one another.
transverse section of a wheat grain is closely exam
with a good lens it is possible to pick out these
outside skins of separate origin which in the millin
the wheat constitute the bran. Underneath com
single layer of cells known as the aleurone or cer
layer. These aleurone cells are almost square in se
and are packed with protein granules and fats—with
or no starch. These aleurone proteins however exer
undesirable influence upon the dough during fermenta
and for this reason the miller excludes them from w
flour along with the bran in spite of their food va
The rest of the berry is seen to be packed with st
cells of varying sizes and the spaces between them
packed with the protein, gluten. This part is the lar
and, to the baker, the most important part of the wh
grain. It is known as the endosperm and contains a s
of food materials for the embryo when it germina
This is the part of the wheat berry which the miller ma
into white flour.

When the wheat grain is cut longitudinally down
crease the outside testa and pericarp can again be obser
as well as the aleurone layer. In this section a much be
idea is obtained of the endosperm, which forms 85
cent. of the wheat berry. The embryo or germ can a
be clearly seen. It consists of three parts—plum
radicle and scutellum. The plumule is the undevelo
shoot and contains the first shoots of the future wh
plant. The radicle is the root centre and contains
root bulb. The scutellum or cotyledon is a modi
seed-leaf and consists of several distinct tissues, the m
important of which, the outermost epithelial layer, secre
the various enzymes required to bring the food stores
the endosperm into a soluble and diffusible state for
use of the developing embryo or seedling. The starch
disintegrated and then dissolved by diastase as m
sugar or maltose, which is converted into glucose

sugar by another enzyme, maltase. The insoluble
n and other proteins are converted into the soluble
mes and amino-acids by appropriate proteolytic
mes; these are absorbed by the scutellum and with
ugar pass inwards to the embryo.



. 33. Longitudinal section of a Wheat grain. Al. Aleurone grain layer. B. beard. Br. bran. C. cuticle. En. endosperm. Ep. secretory epithelium of scutellum. G. germ or embryo. Gr. groove or crease. Sc. scutellum.

n ordinary white flours the germ is largely excluded,
it is present in wholemeal flour and special germ flours.
h flours produce a moister loaf because of the oils in
germ: and because of a certain amount of pre-digestion
the enzymes present, the bread is more easily digested
l has a characteristic flavour. On the other hand,
ause of these enzymes such flours are more liable to
go rancid, unless as in the case of Hovis flour the germ
reated separately before being added to the rest of the
ur.

The approximate composition of the wheat berry is as follows :—

Pericarp	3 per cent.		Starch	65 per cent.	
Testa	2 „		Water	13·5 „	
Aleurone layer	8 „	100	Proteins	13 „	
Endosperm	85 „		Fibre	2·5 „	
Embryo	2 „		Sugar	2·5 „	
			Ash	1·8 „	
			Fat	1·7 „	

Pericarp and Testa. The fused testa and pericarp consist largely of cellulose which is indigestible and of no food value. Wholemeal flour contain much of this tough material and wheatmeal flour contain some of it. It is claimed that in such flours it acts as " roughage " and in the finely divided condition in which it is present irritates the walls of the intestines and encourages the natural peristalsis of the intestinal muscle.

Aleurone Layer. This part of the wheat berry contains valuable food ingredients including proteins, fats and mineral salts. The proteins, however, have an undesirable effect on the ripening of the dough during fermentation and are ordinarily discarded by the miller along with the pericarp and testa as bran or offals. It is present only in wholemeal and wheatmeal and low grade white flour.

Endosperm. This part of the wheat berry constitutes the richest supply of food materials for the embryo. It contains starch and gluten grains along with small amounts of fats and sugars. White flour consists practically of nothing but endosperm.

Embryo and Scutellum. Although this part of the wheat berry contains valuable proteins, fats and sugars, it is normally discarded from white flour because of the enzymes or ferments it contains. As it is present in such small proportions its inclusion in flour would add little to the food value of the flour and the fat and enzymes quickly produce rancidity and a bad flavour. On the other hand it contains the valuable vitamins B_1 and E, which are absent from the rest of the berry and so from ordinary white flour.

nation of Wheat.

n wheat grains are soaked in water and kept at a temperature ut 70 F., germination quickly takes place. The water soaks he cells of the grain and the protoplasm present in the embryo pon the pro-ferments, or mothers of ferments, in the epithelium scutellum and changes them into active ferments. These nts or enzymes are of several types and each acts on one ular food material. The insoluble starch and proteins stored the endosperm are converted into sugars and soluble proteins, nes and amino-acids. These are easily assimilated by the yo which increases in bulk. As a consequence the radicle or centre emerges, shortly followed by the plumule or young . If the wheat grain has not been planted in soil, growth nues until the food supply in the endosperm is used up, when ittle plant withers and dies. If wheat which has begun to inate is ground into flour, the flour and the bread baked from always of poor quality because of the active enzymes and the nt of soluble matter present. Hence the importance of careful ge of wheat before milling. This is generally done in silos in h precautions are taken to prevent sweating of the grain and the s of sufficient moisture to cause germination.

hen the grains are planted in soil the young roots are able to up moisture and mineral salts from the soil and the young shoot s its way steadily upwards through the soil and emerges into open to form leaves which derive food from the atmosphere. mn sown wheat appears above ground while the weather is cold and makes little apparent progress until the warm days of g arrive. Rapid growth is then made, the plant increases in ht and strength and the stem becomes hollow except at the nodes re the leaves appear. In early June the uppermost leaf begins to l and shortly afterwards a flower spike emerges. The wheat t is self pollinated, i.e., male and female parts are found in the e flower. Pollen is also carried from one wheat plant to another nsects and wind. After fertilization the fruits or grains begin rm. When they reach a fairly good size they are plump and and filled with a milky fluid. Later they become solid and ually the plant changes its green colouring for a pale yellow le. Later it turns a beautiful golden colour which so gladdens farmer's heart and indicates that the wheat is ready for harvest.

t all stages of its growth wheat reveals itself as a grass but by ful cultivation and seed selection a modern wheat plant produces verage of six to twelve stalks although some specially fine plants as many as three to four dozen, all bearing fine heads of grain. h head yields from thirty to fifty grains so that a single grain of at may contribute three to four hundred grains to the harvest.

ybrid wheats have been produced by cross fertilization of different ieties, which not only give increased grain yield but are more stant to wheat diseases such as rust, smut, mildew and ergot, produce longer and stronger straw.

The Milling of Wheat.

Historical. Early man probably ate grain without preliminary grinding to flour but even prehistoric times wheat was ground between sto Two stones were commonly used, one being held in hands and the other resting on the floor and more or hollowed to hold the grain. With advance in civilisat the lower stone was artificially hollowed and the up one shaped to fit it. The next stage was the use of ha stones or querns in which the upper stone was rotated o the stationary bottom stone. This primitive type of m is still in use among uncivilised races and in rem districts generally. Further improvements came with t use of larger stones diven by slaves or cattle. This w followed by the use of water wheels as motive power a subsequently windmills. Later still, steam power w utilised. All of these methods are the same in princip Originally the whole of the grain was ground betwe stones and the coarse particles of bran afterwar removed in the dressing by hand sifting of the flou Such stone milled flours were dark in colour because muc of the husk was so finely divided as to pass through th silk sieves, and the quality of a flour was largely judge by its whiteness. The early white bread would h available only to the miller and his richer customers, bu as long ago as the middle of the seventeenth century bra was separated for the use of cattle. Towards the end o the eighteenth century an Austrian, Parr, introduced th practice of high milling, a system of gradual reduction an purification. Roller milling dates from about 1820 bu it was about 1867 that the first complete roller mill wa built, and this at Pesth, Hungary. Roller milling did no start in England until 1887, before which time the mea from the millstones was sifted to remove the bran an germs. The public demand for roller milled white flou has become so great of recent years that at the presen time stone-milling is to all intents and purposes obsolete Later developments have been in improved methods o grain handling, storage, cleaning, conditioning, reductio and artificial bleaching and treating of flour. Recently

has been an effort to popularise flours containing all
ne of the husk and in some cases the germ, but white
prepared by the roller milling process still constitutes
r the greater part of our supply of flour.

Milling Process.

methods by which the miller separates the endosperm from
ricarp, testa, aleurone layer and embryo to produce flour may
ided into the following stages :—cleaning, conditioning, break-
g, reduction, bleaching. We propose to consider each of these
in turn.

aning.

cleaning of the wheat is obviously necessary when it is realised
the grains of all plants growing in the wheat fields are taken
th the wheat. The wheat will also be liable to contain bits of
straw, soils and stones as well as other impurities collected
g transit. The first cleaning process is that of sieving or
ning, in which large fragments of foreign matter such as sticks,
, dirt and soil are removed and only objects of about the same
s the wheat grain will be left in the grain. This consists of
such as oats, barley, rye and poppy and other foreign seeds
h the miller calls " cockle." These foreign seeds are smaller
the wheat grain and are removed by an ingenious separating
hine known as a *cockle cylinder*. It is a cylindrical machine
ing on a horizontal axis. Its inner surface is indented with a
number of holes of such a size that the cockle seeds can lodge
em but not the larger wheat, oats, barley and rye seeds. As
ylinder rotates the cockle lodged in the holes is carried up and
into a stationary tray which passes through the cylinder. In
markably short time the whole of the cockle is separated from
large grains and carried away by an endless screw attached to
tray.

he next process is the removal of the seeds larger than the
at berries. This is effected by an exactly similar cylinder known
barley cylinder in which the holes are big enough to fit the wheat
but too small for the barley, oats and rye. This time it is the
at which is carried up, dropped on the tray, and then removed
neans of the endless screw. The barley, oats and rye are left
nd in the cylinder.

he wheat now passes to the *scourer* in which the grains are
bbed or barged in a rapidly revolving cylinder lined with emery.
ace impurities and the fine hairs at the pointed end of the grain
ed) are very effectively removed by this harsh treatment.

the next stage of the cleaning process the wheat reaches the
ers in which the wheat is dropped into running water. All
icles heavier than water sink to the bottom while the grains
-selves being lighter than water float to the surface. It is
esting to note that up till now the methods of cleaning would

do nothing to remove impurities of the same size as the grains. In this washing process impurities of the same size wheat grain which may have passed through the cockle and cylinders, e.g., small stones, will now be removed.

The wheat next passes to the *centrifugals* or *whizzers* in which dried.

ii. Conditioning.

The wetting of the grain serves another purpose than the washing. It conditions the wheat for break-rolling by making husk tough without affecting the brittle character of the endosp so that the starchy endosperm can easily be powdered while the will not easily be reduced. Great care is necessary in this pro since hard wheats require long soaking and medium and soft wh require much less. The conditioning is completed in stone bins the different samples of wheat blended to make up the partic grist for the mill. The next process is the break-rolling but wheat is given a dry brushing to remove any loose particles an slight steaming before being milled.

Great credit is due to the modern miller for the skill and ingenu he displays in this very effective cleaning of the wheat without wh dirty flours of poor keeping qualities would be the general r instead of the exception.

iii. Break-Rolling.

The actual milling begins with the passage of the grain through series of three or more break-rolls. These consist of a pair of st rollers with finely-fluted surfaces which rotate at different spee The rollers are about 10 inches in diameter and the spaces betwe the flutes and ribs about $\frac{1}{15}$ inch. It is possible to adjust t distance between the rollers for fine or coarse "breaking."

The grain is split open at the crease in its passage through t first break roll and the contents of the grain set free. This separati of the starchy endosperm, known as semolinas or middlings, from t bran or offals is made more complete by passage through sever more break rolls. Some of the endosperm is unavoidably reduc to flour at each break and is removed by sieving through woven wi sieves before the coarse "overtails" are passed on to the next brea The flour formed at this early stage contains dirt from the furro of the grain that has not been removed by the previous cleaning the wheat.

After each break the endosperm is more and more completel separated from the bran, and the semolinas and middlings are mad to travel in the opposite direction to a current of air in purifiers separators, which blows away fine fluffy particles of husk which ar collected and removed.

iv. Reduction.

The starchy, gritty semolinas and middlings are now ground t flour by passing through reduction or grinding rollers. These ar not fluted like the break rollers but quite smooth and set clos

er. The flour is then " dressed " by sifting through fine silk
Any particles which do not pass through the silk sieves are
passed through the rollers to grind them finer.

regards the germ, part of it is removed with the bran or
a very small amount of it passes through the silk sieves along
he flour but most of it is removed after reduction. This is
se the high fat content of the germ causes it to be pressed flat
on the reduction rollers instead of being crushed to powder.
ius too large to pass through the silk sieves and is actually the
ning to be separated in the milling of flour.

eaching.

bleaching plants used in flour mills are of two types : (*a*)
ical ; (*b*) electrical.

chemical bleaching plant consists of apparatus for the produc-
of oxides of nitrogen. These gases are passed into an enclosed
h through which the flour is passed by conveyors. A few
ds treatment is all that is necessary. Over-bleaching produces
r of very inferior baking qualities.

the electrical method the higher oxides of nitrogen are produced
with some ozone by the action of an electric arc on the
gen and oxygen of the air. Chlorine gas, " beta gas " (99·5 per
chlorine and 0·5 per cent. nitrosyl chloride), nitrogen trichloride
), and benzoyl peroxide are also used in flour bleaching.

e practice of bleaching flours probably arose out of the public's
and for white flour. Natural unbleached flour is of a slightly
wish tinge due to the fat content and the colouring matter
tine it contains. It is claimed that the bleaching of flour
ts in its partial sterilisation and therefore improves its ageing
maturing qualities. It is, however, chiefly used to make lower
e flours dead white. High grade flours are not improved by
ching and are seldom so treated. The by-products of the
ous gaseous bleachers used are of such a nature and of so small
ncentration in the flour treated that they are quite harmless to
consumer. Finally the finished flour is weighed and packed by
hinery and taken to the flour stores to mature. The offals also
graded and packed by machinery. Generally speaking 100 lbs.
heat yield about 70 lbs. of flour.

typical result of milling is :—

dard Patent Flour ...	72·6 per cent.		ordinary bread flour.
Grade Flour ...	0·5	,,	rich in protein.
est Grade Flour ...	1·9	,,	dark flour containing most of the germ.
ts or Middlings ...	11·6	,,	fine bran with some flour.
... ...	13·4	,,	the " hull " or husk.
	100·0 per cent.		

Grades of Flour. It is difficult to draw up a comprehensive table of the various grades and types of flour because different millers use different names for the same product and different districts have their own terminology. Generally speaking the smaller the percentage of the total weight of the wheat included in the flour the higher is its grade. Thus a "First Patent" contains 30-40 per cent. of total weight of wheat, a "Second Patent" 50-60 per cent. A "straight run" flour contains 70 per cent. of the total weight of the wheat. "Households" are usually straight run flours. Wholemeals contain the whole of the wheat grains ground into flour, while a wheatmeal is a flour from which only the coarser bran particles have been removed.

It is interesting at this stage to compare the composition of an average flour with that of the wheat grain already given.

Flour.		*Wheat.*	
Starch ...	72·0 per cent.	Starch ...	65·0 per cent.
Water ...	12·5 ,,	Water ...	13·5 ,,
Proteins	12·0 ,,	Proteins	13·0 ,,
Fibre ...	—	Fibre ...	2·5 ,,
Sugar ...	2·0 ,,	Sugar ...	2·5 ,,
Fat ...	1·0 ,,	Fat ...	1·7 ,,
Ash ...	0·5 ,,	Ash ...	1·8 ,,

There is a notable increase in the proportion of starch and a decrease in the proportions of protein, fat, ash and fibre due to the removal of bran, aleurone layer and germ.

Flour. Wheat flour, as we have seen, is the finely divided and carefully dressed product obtained from wheat by a complicated milling process. It is a complex mixture of carbohydrates (starch and sugars), proteins, fats, mineral salts and water derived from the endosperm of the wheat grain. In appearance it is a white or creamy white powder with a faint pleasant smell. It has a "nutty" and slightly sweet taste. When squeezed in the hand it shows a tendency to stick together but quickly falls apart again when the pressure is released. When mixed with water it forms a plastic mass known as dough.

Properties of Flour Constituents.

From whatever type of wheat flour is derived its chemical composition varies only within narrow limits. The constituent present in largest nt is *starch* which may form as much as 72 per cent. flour. Like all forms of starch it consists of minute les or cells which are generally round and provided a dark spot (hilum) and marked with concentric (striations). Its properties are similar to those of starches. Wheat starch, like other starches is scopic and is the chief cause of the moisture absorb- ualities of flour on keeping. Large proportions of n in a flour give it a whiter colour and lead to the ction of smaller closer loaves.

Second in point of quantity and first in point of baking quality is the *gluten*. This is the chief in constituent of flour and it is its presence which s wheat the chief bread-making cereal. When ly separated from flour by kneading dough under a m of water and washing out the starch it is a greyish w sticky elastic substance with practically no taste nell. When moist gluten is left exposed to air it dly putrefies and gives off obnoxious gases. Its y elastic character assists in the retention of the on dioxide gas formed during fermentation of dough east and thus causes the dough to rise. When heated adually becomes tough and hard almost like glue and ot again be transformed into the plastic condition. n more strongly heated it turns black and gives off a l of burnt hair or feathers indicating its protein acter. Eventually it burns completely away. During baking of bread the gluten becomes hard and acts as framework of the loaf which keeps its shape even after gas which caused its inflation has escaped. When en is carefully air-dried at a low temperature it mes glossy and brittle and may be ground to a fine der which still retains its elastic properties when ed with water. It is this form of gluten which is in the baking of *gluten bread* for diabetic patients to m starchy foods are injurious.

Composition of Wheat Flour (Osborne & Voorhees

	Spring Wheat.			*Winter Wheat*		
	Nitrogen	× 5·68 =	Protein	Nitrogen	× 5·68 =	Pro
Glutenin	... 0·8245	=	4·863	0·7346	=	4·1
Gliadin	... 0·6977	=	3·963	0·6884	=	3·9
Globulin	... 0·1148	=	0·624	0·1148	=	0·6
Albumin	... 0·0657	=	0·391	0·0603	=	0·8
Washings	... 0·2239	=	1·272	0·1552	=	0·8
Others (Coagulum & Proteose)	0·0784	=	0.445	0·1170	=	0.66
Total	... 2·0050	=	11·415	1·8703	=	10·60

Chemically, gluten consists in the main of two substa —gliadin and glutenin.

American spring wheat flours which contain l percentages of gluten with large proportions of glute are strong flours and yield large loaves. English wi wheat flours with small percentage gluten of low glute content are weak flours and yield small loaves (" Strength " of flour).

Soluble Proteins. There is also in flour protein mate of another kind which unlike glute soluble in water and referred to as *soluble proteins*. Th soluble proteins are much like white of egg in charac and are called globulin, albumin and proteose. Fl from germinated wheat contains increased proportions these soluble proteins and it seems probable that th are formed by enzyme action from gluten not only germinating grain but also in dough during fermentati

Water. Although flour ordinarily seems an extreme dry substance it always contains a certa amount of water absorbed from the atmosphere by t hygroscopic starch cells as well as that carried over fr the endosperm. The amount of the absorbed moistu varies considerably according to the conditions und which the flour is stored ; it is usually between 11 and per cent. When stored for some time in a moist atm sphere flour actually gains in weight, and loses in weig when stored in a dry atmosphere. These variations m

nt to several pounds per sack of 280 lbs. If the content of a flour rises above 14 per cent. there is a er of bacterial action and mould growth, and such will keep badly and develop acidity. It should be d that the amount of absorbed moisture in flour has nnection with the water necessary for dough forma- which depends upon the gluten and not upon the h of the flour.

R. There is present in flour a small quantity of a disaccharide sugar which is similar in composition properties to cane sugar. It is upon this sugar that yeast in dough acts and from which the carbon de is produced to aerate the dough. The quantity gar in flour varies with the type and grade of flour een 1 and 2 per cent. The sugar of flour has a derable effect on the bloom of the crust of the loaf g to its caramelisation during baking.

Different types and grades of flour contain varying amounts of fat—the higher grade flours containing and the lower grade and straight run flours con- ng most, about 1·04 per cent. Products such as is and other germ flours are very rich in fat because of inclusion of the germ. When separated from flour oil is a pale yellowish liquid without taste or smell. wheat oil, as it is called, is particularly rich in the -sterility vitamin E. The yellow colouring matter of , carotene, is present in the oil, and it is with this that anti-neuritic vitamin B_1 is closely associated.

ERAL SALTS. The mineral salts present in flour are left behind as a fine white ash when the nic constituents are completely burnt away. They ist chiefly of phosphates of calcium, magnesium and ssium with traces of iron and aluminium sulphates. se mineral salts of flour that are soluble act as yeast s and buffers during fermentation of dough and help ne stabilisation of the gluten.

RE. All grades of flour below patents are liable to contain traces of bran. Unless present in eciable quantities they are unlikely either to affect colour or baking qualities of the flour.

Physical Properties. The most important phy properties of flour are its co strength, absorption power and stability.

Colour. It is generally taken for granted that flo white but actually its colour may vary f dead white to greyish white, brownish grey and cre yellow. These variations in colour are due to a var of causes such as the presence or absence of bran parti the species and variety of wheat, and the use of bleac agents. Valuable indications of the character of a f can be obtained from examination of its colour. Bro speaking whiteness is an indication of large percenta of starch, greyness indicates poor quality, yellown suggests high gluten percentage, brownness is proba due to bran particles, while dead-whiteness is an alm certain sign of bleaching. The usual method of judg the quality of a sample of flour is by comparison wit standard sample by the *Pekar method*. The two samp are placed side by side in small heaps on an oblong pi of plate glass and pressed down flat so that they touching. The colour of the two samples are th compared. The glass is then very carefully lowered und water starting with one corner and gradually sliding the whole glass without allowing any flour to slip or a air bubbles to form in the flour. The glass is withdra and the colours of the two samples compared once mo Previous slight differences are now more distinct a become still more marked when the flours are dried.

Strength of Flour. While this is one of the mo important properties of a flour from bakery standpoint it is also one of the most difficult define with exactness. Broadly speaking a strong flo is one which will absorb a large amount of water in t formation of dough and consequently produce a big loa Since it is the gluten of flour which absorbs water dough formation strength is obviously connected with t gluten of the flour. The more gluten a flour contains t more the dough will be able to retain the carbon dioxi formed during fermentaiton. Consequently the doug will rise more and when baked will produce bigger loave

ver, as already pointed out, the quality of the gluten nportance as well as the quantity. The greater the rtion of the tough elastic glutenin and the smaller oportion of the soft sticky gliadin, the better the will be able to resist the strain put upon it by the s of carbon dioxide and the action of yeast enzymes the dough during fermentation. (See also page 214.)

commercial bread making where long fermentation sses are used, strong flours are essential. Such would however be extremely difficult to work by and for ordinary household purpose soft or medium ore convenient.

alue of Flour.

easing importance is being attached at the present time to ydrogen-ion concentration of flours. It has a considerable ce on the colloidal behaviour of the proteins in flour and upon tivities of the enzymes present. The hydrogen-ion concentra- f a flour also gives an indication of its condition and is one of ctors determining loaf size and the possibility of rope disease ad.

hydrogen-ion concentration of a flour is largely determined by rotein substances and soluble phosphates it contains. These very efficient buffers and give a hydrogen ion concentration ut pH6. It is generally found that higher grade flours have a pH value than lower grade flours, probably owing to the small ntent and consequently diminished buffer action due to soluble hates.

ring the fermentation of dough the pH value is lowered by the y developed and successful aeration is largely dependent upon act. This is because fermentation proceeds most quickly at 7; gluten is most coherent and elastic at this concentration. rade flours, particularly when containing bran with their larger ntages of soluble phosphates and consequent large buffer , do not reach this pH value during fermentation as quickly as grade flours. This change in pH value is however very ially helped by the addition of so-called "improvers" such as hosphates and malt extract.

rption Power.

absorption power of a flour refers to the amount of water is required to form a dough of a given consistency, and is usly like the strength of a flour dependent upon the quantity quality of the gluten. An average flour will absorb between d 75 per cent. of its own weight of water. During the sub- nt baking of the dough some of this absorbed water is lost as in the oven until the percentage of water in the resultant

bread is between 35-40 per cent. It is generally found that a which absorbs a large proportion in dough formation loses a small proportion during baking and vice versa.

Stability.

A stable flour is one which does not easily collapse under the s of fermentation and the all important factor is again the gl It is important to notice here that the purpose of salt in breadm is not merely to flavour the bread but also to stabilise the gl The salt does this by increasing the strength of the gluten and by causing the yeast to ferment at a steadier rate. Thus the gl is better able to resist the more uniform strain put upon it du fermentation.

Flour Improvers. Since flour is a natural prod derived from wheat it will vary character from season to season according to the harv Such variations are undesirable from the baker's a housewife's point of view, and the miller attempts produce a standard product by the use of mineral s stances to make up for any deficiencies in a particu flour. The commonest substances used for this purp are Epsom salts, Glauber's salt, potassium and ammoni persulphates, and acid phosphate of lime. Alum was a at one time used as a mineral improver but its use is n illegal in England. Very small quantities of these su stances have a marked toughening or astringent action the gluten whereby it is enabled to keep inside the dou a greater proportion of gas during fermentation with t consequent production of bigger loaves. They also act yeast foods and by increasing fermentation further impro the baking qualities of a flour.

It will be noticed that salt has not been included in t list of mineral improvers. Although a mineral substan salt is not an auxiliary but an essential in order to stabili the gluten.

Baking Aids and Enriching Agents. In addition to the fundamentals bread-making—flour, water, yea and salt—many other substances a frequently added either as yeast foods or enriching agent Among such products may be mentioned milk and mi powders, malt products, fats and oils and sugar. W will consider briefly the advantages derived from each.

AND POWDERS. The use of milk and milk powders obviously increases the food value of bread especially in mineral salts are so valuable to children. In addition, the s improved in appearance and texture while the is softer and more moist. The milk sugar (lactose) fermented by yeast so that milk bread has a r taste than ordinary bread.

PRODUCTS. These may be used in the form o malt extract or malt flour. Their value the enzyme diastase which they contain. This es the starch of dough into a disaccharide sugar and sts fermentation with consequent increased volume. od value and digestibility of the loaf are increased e bread possesses a characteristic flavour.

AND OILS. Here again the food value of the bread is increased by the addition of an ingre- in which bread is deficient. A softer moister crumb duced and the keeping qualities of the loaf improved.

R. Sugar acts as a yeast food though it should be remembered that there is sufficient natural sugar ur for gas production. The chief advantages are in ved colour and bloom of the loaf.

o points must be emphasised about such baking aids. y, more than one such substance can be used in nction with another and secondly, the use of too quantities of such enriching agents is worse than not them at all.

Special Types of Flours

S. **Wholemeals** are prepared by grinding the whole of the wheat grain without separation of ran or germ. Such meals contain in addition to the ituents of ordinary flour cellulose from the bran ats from the germ as well as small amounts of other rials. They are dark in colour, coarse in texture and ce a dark coloured loaf. They are rich in vitamins iboflavin and Nicotinic acid.

Wheatmeals do not contain all the ingredients
wheat grain. They are prepared either by sepa
the germ and coarser particles of bran or by mix
low-grade white flour with a proportion of offals.
are not as dark as wholemeals and finer in texture.

Germ Meals.—Quite a number of these are on the m
as proprietary articles. One of the best known, H
is prepared by mixing 75 per cent. white flour with 2
cent. cooked germ. The germ is mixed with the nece
amount of salt for bread making and then partly co
by superheated steam. This cooking produces a chara
istic malty flavour and destroys the enzymes of the
as well as prevents the oil from becoming rancid.

Malted Meals.—Many of these are obtainable and
usually prepared by mixing malt flour obtained
malted barley with wheat meal.

Self-Raising Flours.—These are simply white
with the necessary aerators added to them for con
tionery purposes. The necessary proportion of,
example, cream of tartar and bicarbonate of soda
carefully sieved and dried and then thoroughly mi
with dry flour. Their convenience is their only advanta

Wheat Products. Semolina (wheaten) is granula
hard wheat, prepared from the cen
part of the grain when the wheat is ground by millsto
placed so far apart as not to crush it completely to flo
Some wheats of dry hot countries, like Italy and Fra
being hard and rich in gluten, are peculiarly suited
the preparation of semolina.

Macaroni, Vermicelli, Italian Paste and Spaghetti
all dried paste made from the semolina of hard red wh
of the South of Russia and Southern Italy, and m
recently of Canada and the U.S.A.

Oatmeal. Oats are the seeds of Avena sativa in ma
varieties, which are cultivated in cool temper
climates under conditions of soil, elevation and sunshi
less favourable than those suitable to wheat. In t

y they are or were the food crops of the lower hill
of Wales, the Pennines and Scotland and until com-
ely recent times were the staple bread food of the
g and artisan population. Oatmeal with or
t milk was the mainstay of the Scotch peasantry,
t bread or haver-cake is not yet altogether extinct
the dalesmen of the Lake District and the York-
Dales.

meal is milled in the four stages of coarse, medium,
nd patent. Rolled oats, now largely displacing
al with the ordinary town consumer, have the
tage of being already heat treated and consequently
easily and quickly cooked. Good quality rolled
hould show each flake separate and be quite free
husk. In either form oats have a high content of
n and various mineral salts, including calcium,
nd phosphorus, and are definitely richer in fat
wheat. The protein is deficient in gluten and
uently oat flour will not form dough strong enough
ke loaves. The presence of phytin hinders the
tion of calcium and thus may cause rickets.

This is the grain of Hordeum. When used in
the home it is mainly as "Pearl Barley" in
the kernel is freed from the husk and polished,
Scotch Barley" which retains some of the husk
Barley meal is finer ground than pearl, but is
rely used as a food cereal. "Patent barley" is
nest ground and purest and has limited domestic
or making barley water. Barley grain or corn is
ally used as the source of malt for the making of

ze or Indian Corn is the grain of Zea mays, a native
erica, but now fairly widely cultivated in warm
rate and sub-tropical climates. Corn-meal is
l in the white and yellow varieties from white or
maize, and though extensively used as a food
in maize growing countries has never established
s such in this country. Cornflour is derived from
dosperm of the maize grain and is almost pure
, its protein is low in amount.

Rice, the grain of Oryza sativa, is cultivated in sw fields in most eastern tropical countries, as India, and Japan, and also in America, and to a certain li extent in Spain, Italy and Egypt. Many distinct va and qualities of rice, according to the country of o and the particular regions or even estates where culti are on the market and may be recognised fairly with practice. Rice may be " polished " or " unpolis in the former the outer " silver skin " has been rem and with it the vitamin B_1 the absence of which c beri-beri (see page 100.) Various derivatives of m are marketed—rice flour, ground rice, granulated rice corn and rice-semolina—each having its parti use in the home or in industry. The grains are ri starch—most laundry starch is rice starch—but po proteins and fats.

True Sago is produced from the pith of the Sago growing in Malay, the Philippines, Borneo and I The pith after being scooped out of the planks of the is pulped with water and then strained. The starch w settles is washed, drained clear of water and then dri the sun. The flour is granulated by being passed thr a sieve and shaken. The grains are roasted for a minutes, being changed into a nearly transparent glutinous substance. After a further roasting on metal plates they become smaller and harder and tak the characteristic dark greyish colour. The dried g are sifted into the three grades, large, medium and s sago. By far the greater proportion of what is sol sago is not true sago, being prepared from tapioca.

Tapioca is a food starch prepared from the undergro stem of Cassava or Manihot, which is grown in the tro of America, Africa and Asia (Java, Penang and Singap The rhizomes are dug up, washed, scraped and pul Juice, pressed out of the pulp, is boiled down to a t black fluid. The pulp is washed with water, and so f from a poisonous constituent ; the starch is left to s and the water drawn off. The starch after drying in sun is made into tapioca by partial roasting on hot pl during which process the granules burst their cellu

COMPOSITION OF COMMON CEREAL PRODUCTS.

Per lb.	Protein.		Fat.		Carbohydrate.		Calories
	grams	per cent.	grams	per cent.	grams	per cent.	per lb.
Wheat Flour ...	45·8	13·3	7·3	1·5	342·5	72·7	1660
Oatmeal	54·0	16·1	39·0	7·2	317·5	67·5	1886
Oats (rolled) ...	59·4	14·7	29·5	6·2	315·2	69·8	1809
Barley (pearl) ...	31·7	8·5	3·6	1·1	362·4	77·8	1650
Maize meal ...	40·8	9·2	8·6	1·9	334·0	75·4	1620
Rice	26·8	8·0	1·8	0·3	364·2	79·0	1620

coatings and liberate the inner gelatinous contents. sticking together form nodules. These are kept sm constant stirring during heating, and form flake ta After sun drying the starch is powdered, made into and granulated by being passed through a sieve. finally roasted. Tapioca starch is largely soluble s and consequently dissolves to a certain extent in w as well as takes up water to form a jelly, when wa with water or milk, and this much more qu than rice.

Arrowroot, like tapioca is a starch derived from u ground stems, in this case of Maranta, a plant grow various parts of the two Indies, tropical Africa America. St. Vincent is the only important expo source. It is manufactured largely on the line tapioca as far as the stage of precipitating the st which is then dried in copper pans with a gentle It is sold in two forms ; granular and pulverised. tapioca it dissolves slightly in water, and quickly s up in warm water or milk, and is consequently e digested-- hence its use as an invalid food.

EXPERIMENTS ON WHEAT AND FLOUR

Experiment 1.

To examine plants of the Common Cereals.

Procure specimens of stalks of ripe wheat, oats, barley an Examine each in turn, noting the type of straw, chaff and Compare with wild meadow grasses.

Experiment 2.

To examine the structure of Wheat Grains.

Soak some wheat grains in water for a day. Examine general appearance and note the shape and positions of the b embryo and furrow. Cut a wheat grain lengthwise and examin sections with a hand glass. Dip into a dilute solution of io Name the various parts you can see. Cut a grain transve again dip in iodine solution and examine the section as be Name the various parts.

Experiment 3.

To germinate Wheat grains.

Place a double layer of white blotting paper inside a glass b so that it fits the sides closely. Between the blotting paper

place a number of wheat grains that have been previously n water. Pour a little water into the beaker and place in rner. Examine the grains from time to time and observe ral stages of germination.

Experiment 4.

To compare various types of Flour.

side by side on filter papers, samples of whole meal, wheat erm and ordinary white flour. Observe their differences e naked eye and with the help of a hand glass. Compare the and taste of the various samples. What characteristics ou expect to be shown by loaves made from the various

Experiment 5.

timate the quality of a sample of Flour by the Pekar Test.

side by side on a piece of plate glass or white wood, equal ies of a flour that is known to be of high quality and of the at is to be tested. Press the samples down firmly with a so that the two samples are contiguous. Compare the of the two samples. Then very carefully lower the plate wood under water, starting with one corner and gradually in the whole glass or wood without allowing any flour to slip air bubbles to form in the flour. Carefully withdraw and ompare the samples. Now place the samples on one side to d then compare again. Any previous slight differences in are now much more distinct. Draw conclusions from this to whether the gluten content is high or low, whether bran es are present and whether the flour is bleached or unbleached.

Experiment 6.

To separate the main constituents of White Flour.

about 20 grams of white flour in an evaporating basin and into a dough with about 11 ccs. of water, mixing the flour ter together with a spatula or solid glass rod When the is of proper consistency, leave it to stand for about 40 s (why ?). At the end of this time take it in the hands and between the fingers in a large beaker of lukewarm water. e until the water coming away from the fingers is no longer Squeeze as much water as possible from the gluten left in ands work it into a coherent mass and place it in a basin ut 10 minutes. Allow the contents of the beaker to settle ; sediment of wheat starch will deposit at the bottom. In nner the two main constituents of white flour, starch and are separated.

Experiment 7.

To identify the food materials present in White Flour.

(*a*) **Starch.**

Decant the water from the deposit of wheat starch obtain the previous experiment. Mount a sample of the starch on a and examine microscopically, noting the shape and size starch grains. Heat a small amount with water in a beaker a obtain a thin starch paste, pour a little of this into a test tu water and add iodine solution. The deep blue coloration ind starch, and the colour disappears on heating and reappears on co

(*b*) **Gluten.**

Examine the sample of wet gluten obtained in Experime Note particularly its colour, elasticity, toughness and coher Of what importance are these properties in the baking of br Leave a small piece of the wet gluten in a basin for a few Like all proteins it rapidly putrefies and gives off an offensive o Dry the rest of the gluten and then carry out the following test proteins with it :—

(i) Heat a small amount on a piece of broken pot and n the fumes smelling of burnt hair or feathers.

(ii) Heat a small amount in a test tube with soda-lime. the fumes evolved for ammonia by smell and moist litmus. The gluten may also be tested as a protei other reactions if thought desirable as set out on page

(*c*) **Fat.**

Shake up a quantity of flour with ether in a corked conical f (taking care to have no flame in the neighbourhood and not to w the flask with the hand). Leave to stand until the flour settle the bottom and then remove the ether extract by decantatio filtration. Evaporate away the ether in a basin on a water b A small quantity of oil will be left behind which will feel greas the touch and when a drop of it is poured on filter paper will re it translucent.

(*d*) **Mineral matter.**

Heat a small quantity of flour in an open crucible until no mo it will burn away. The small amount of white ash left behin mineral matter. Shake up chloroform and flour in a separa funnel and leave to stand. The flour being lighter than chlorof rises to the surface and mineral matter being heavier settles to bottom. Withdraw the chloroform layer and either evaporate the chloroform on a water bath or recover it by distillation. residue left after the removal of the chloroform is the mineral ma which has been added to the flour as an improver.

(*e*) **Water-soluble Ingredients.**

Place about 10 grams of flour in a conical flask and shake vigoro with about 100 ccs. of water. Allow the flask to stand until the f

ettles to the bottom. Decant or filter the top liquid into orating basin and evaporate to dryness on a water bath. uble residue consists of sugars, soluble proteins and mineral

Experiment 8*.

v the effects of various chemicals on the character of gluten.

nd by means of V-shaped glass rods equal pieces of gluten ers containing 100 ccs. of the following: (*a*) tap water; er containing a trace of free acid; (*c*) water containing a free acid and a trace of sodium phosphate; and (*d*) water ing a trace of free acid and a trace of sodium chloride; and r containing a trace of free acid and also a trace of sodium e. Examine daily and note the order in which the gluten grates. Report on the significance of these experiments.

Experiment 9.

To test whether a Flour has been Bleached.

not easy to test whether or not a flour has been bleached, ne indication may be obtained from the Pekar test, for heavily d flours show a greyish tint, and from the colour of the xtract containing the oil of the flour.

three commonest bleaching agents are nitrogen peroxide, e and chlorine compounds, and benzoyl peroxide and may cted in the following ways.

rogen peroxide.

e about two grams of the flour in a test tube with about of water. Add five or six drops of Griess-Illosvay reagent, he test tube and shake. The immediate production of a olouration indicates nitrogen peroxide bleaching.

Griess-Illosvay reagent is prepared by dissolving 0·5 gms. nilic acid in 50 ccs. of glacial acetic acid to which 100 ccs. r have been added and then adding this solution to 0·1 gm. of hthylamine in 20 ccs. of boiling water. The solution should hly prepared before use.

orine and Chlorine compounds.

e are difficult to detect with certainty for only small quantities d and chlorides are already present in the natural mineral flour.

are an ether extract in a corked conical flask. Allow to nd then decant the ether extract. Evaporate on a water nd note the colour of the oily residue.

nzoyl peroxide.

5 gms. of flour with 7 ccs. of a potassium iodide solution into in an evaporating basin and heat on a water bath. The ance of dark spots on the surface indicates benzoyl peroxide ng.

Experiment 10*.

To identify mineral improvers present in a Flour.

If the chloroform test already described has given po evidence of added mineral salts the following tests may be us identify them :—

(*a*) **Chlorides.**

Shake the flour with distilled water, filter, and add dilute acid and silver nitrate solution to the filtrate. A white preci of insoluble silver chloride indicates the presence of chlorides.

(*b*) **Sulphates.**

To a filtered water extract of flour add dilute hydrochloric and barium chloride solution. A white precipitate of ba sulphate indicates the presence of sulphates.

(*c*) **Phosphates.**

Add a few drops of dilute nitric acid and 3 or 4 ccs. of ammon molybdate solution to a filtered water extract of the flour and to boiling. A canary yellow precipitate indicates that phosph are present.

N.B.—Since chlorides, sulphates and phosphates are no constituents of flour some slight positive evidence of t presence is to be expected. In any case of doubt as to whether mineral salt is a natural constituent of the flour or an added ingredi comparative tests should be carried out with a flour that is kn to be unadulterated.

(*d*) **Persulphates.**

Prepare a benzidine solution by dissolving 2 gms. of benzidin 100 ccs. of alcohol. Add a few drops of this solution to a f paste consisting of 4 gms. of flour and 5 ccs. of water. The pres of dark blue spots on the surface of the paste is a definite indica of the presence of persulphates.

(*e*) **Alum.**

Mix into a paste 5 gms. of flour, 1 cc. of ammonium carbon solution, 5 ccs. of water and 1 cc. of logwood extract. Alum ca a purple colouration while an unadulterated flour gives a pale p colour.

Experiment 11.

Simple analysis of Flour.

(*a*) **Estimation of Moisture.**

Weigh out accurately 5 gms. of flour in a previously weig basin and dry in a steam oven at 100°C., until there is no furt loss of weight. The flour should then be allowed to cool in desiccator before being weighed again on account of its hygrosco nature. When the weight is constant calculate the percentage moisture in the original flour. The percentage usually va between 10 and 14·5. Above this bacterial action and moulds affect the keeping qualities of the flour.

imation of Mineral matter.

gh out accurately about 2 gms. of the flour into a previously l crucible. Heat the crucible, at first gently and then strongly ll organic material is burned away and only a white ash is ool and weigh. Re-heat and re-weigh until the weight is nt. From the weight of ash work out the percentage of l matter. The ash of white flour should not exceed 0·7 per Wholemeal, wheatmeal and white flours to which mineral ers have been added will all show increased percentages.

imation of Gluten.

gh out 20 gms. of the flour in an evaporating basin and make lough with 11 ccs. of tap water by means of a spatula or glass Allow the dough to soak for at least 30 minutes in water in a After this, work the dough between the fingers to remove arch and other ingredients. The water used should be at 30 C., and renewed from time to time until no further turbidity nced. Now take the gluten in the hands and work it into a nt mass. Place aside for about 10 minutes and again work in nds to squeeze out any surplus water. Weigh the moist This weight multiplied by 5 gives the percentage of wet in the flour. When divided by 3 the approximate percentage gluten in the flour is obtained, since gluten absorbs almost twice its own weight of water.

ore accurate result of the percentage of dry gluten may be ed by drying the wet gluten in a drying oven until a constant is obtained. The percentage of dry gluten can then be ted. A flour suitable for breadmaking purposes should in at least 11 per cent. of dry gluten.

imation of Water-soluble Extract.

nty gms. of the flour are accurately weighed in a previously d conical flask and exactly 200 ccs. of tap-water added from a ring cylinder. The flask is shaken for about 10 minutes and llowed to stand until the flour settles to the bottom. The top is then filtered into a second flask and exactly 50 ccs. of the are transferred to a weighed evaporating basin and evapo- to dryness on a water-bath. The basin is finally dried in a oven until it ceases to lose weight. The increase in the of the basin is a measure of the soluble extract from 5 gms. flour, and the percentage is obtained by multiplying by 20. esult obtained should be between 3 and 6 per cent. An ionally high result is probably due to the flour having been from sprouted wheat.

imation of Fat.

nty gms. of previously dried flour is placed in a small dry conical flask and well shaken with about 50 ccs. of ether. quid is allowed to settle and then carefully decanted through filter paper into a weighed 250 ccs. flask. The remaining s again thoroughly shaken with a further 50 ccs. of ether and p liquid after standing decanted through a filter paper into

the 250 ccs. flask. This extraction with ether is carried out
further 50 ccs. of ether and the weighed flask then placed
water-bath and attached to a distillation apparatus. In th
the ether is distilled off and collected in the receiver. The ext
fat remains in the flask as a pale yellow oil. The flask is dr
the outside, allowed to cool and then weighed. The incre
weight is due to the fat extracted from 20 gms. of flour an
percentage is obtained simply by multiplying by 5.

(In carrying out this experiment it should be remembered
ether and ether vapour are highly inflammable.)

Should one be available the fat from flour can be more effec
extracted by the Soxhlet extractor.

The percentage of fat shows a very wide variation in dif
types of flour. Thus high-grade roller-milled patent flours
contain about 1·0 per cent., wholemeal flours contain a h
percentage of fat, while "germ" flours of the Hovis type
contain as much as 5 per cent. fat.

Experiment 12*.

To determine the percentage acidity of a sample of Flour

Mix 10 gms. of the sample of flour with distilled water to a sm
cream. Transfer completely to a 100 ccs. graduated flask
make up to exactly 100 ccs. Stopper the flask and shake freque
for several hours. Allow to stand for half an hour. Filter thr
a dry filter paper and by means of a burette transfer 50 ccs. of
filtrate to a beaker. Titrate with N/100 caustic soda from a bu
using phenol pthalein as indicator. Calculate the acidity as l
acid. An unduly high value denotes the presence of acid impro
in the flour or that the flour is old.

Experiment 13.

To measure the water-absorbing power of a Flour.

Twenty-eight grams of the flour are weighed out into an evapo
ing basin and water added from a burette in small quantities
time. The water and flour are mixed together with a spatula t
a dough of the proper consistency is obtained. The volume of w
required is then read off from the burette. At least three determ
tions should be carried out and the average result calculated.

Since 1 cc. of water weighs 1 gm., the number of ccs. of w
will give the weight of water in gms.

Further as 1 gallon of water weighs 10 lbs., the number of cc
water will also give the number of gallons of water required
sack of flour (280 lbs.), e.g.

If 28 gms. of flour require 14 ccs. of water to make a dough.

28 gms.	,,	,,	14 gms.	,,	,,	,,
28 lbs.	,,	,,	14 lbs.	,,	,,	,,
280 lbs.	,,	,,	140 lbs.	,,	,,	,,
280 lbs.	,,	,,	14 gallons	,,	,,	,,

Experiment 14.

xamine a Sample of Bread (White, Brown and Wholemeal).

condition.

ine the external appearance of the loaves noting particularly m, colour, volume and shape.

nternal examination cut a slice from the middle of the loaf te the colour, texture, flavour, moistness and vesiculation.

e of starch grains.

microscopic slides of both crumb and crust and note whether rch grains are burst or unburst.

sence of live yeast.

some of the crumb to a 10 per cent. glucose solution at 30°C. ve for 24 hours.

the resulting solution for alcohol by the iodoform test with solution and caustic soda solution.

sence of dextrin and sugars.

h some of the bread with water in a mortar and filter. Add rate in small quantities at a time to 6 ccs. of 95 per cent. . If a precipitate is formed continue to add the filtrate volume of 10 ccs. is obtained. At this concentration dextrin ble and starch insoluble. Filter and divide the filtrate into rtions. Test one portion with iodine for dextrin and the portion with Fehling's solution for sugars.

CHAPTER XIV.

BREADMAKING.

Bread may be defined as the product obtained by ba a mixture of flour, water and salt which is made po or vesiculated by the use of yeast or some other mea aeration. By whatever method the bread is aerated made lighter and spongier in texture and its digestib and attractiveness very considerably increased. I compare the sodden "damper" baked by the squa in the ashes of his camp fire, ship's biscuits or the tack of the army with a well-baked loaf of bread easy to realise the advantages obtained by aerating.

Raising of Bread. The earliest method of aera consisted in leaving a small portio dough from one baking to the next. This left- dough or leaven was really a form of virgin barm; yeast cells it contained being derived in the first p from the atmosphere. When this leaven was mi with the next batch of dough it contained suffic yeast cells to lighten or leaven the bread produ Such bread was a dark coloured cake often with a ra sour flavour due to invasion by lactic bacteria, but no doubt superior to the primitive bread made in ea times by simply covering a round pasty mass of coar ground grain and water with red hot ashes and scrap away the ashes when they became cold. Bread wh has not been aerated is known as unleavened bread is still eaten by Jews at the Feast of the Passover commemorate the hurried departure of the Israelites fr Egypt. Except for this ceremonial use the ancient lea is now almost entirely superseded by yeast; at leas civilised countries.

Modern methods of aeration can be divided into th main types; mechanical, chemical and fermentation.

Mechanical. 1. The aerated "bread" sold in A.B shops in London and in many contin tal towns is made by placing flour with the necess

n a strong iron vessel fitted with a mechanical . Water saturated with carbon dioxide under re (similar to soda-water) is then added and ghly incorporated with the flour by the mechanical . The dough is eventually forced out of the iron by the force of the gas, moulded into loaves and y transferred to the ovens. The expansion of the y the heat of the oven and its efforts to escape ce the spongy texture of aerated bread.

Although not used for breadmaking another nical method of aeration may conveniently be oned at this point. In certain cases, the flour is with either water or milk to form a batter or thin and then beaten or whisked. Bubbles of air e entangled in the mixture which is quickly baked they are able to escape.

A third example of mechanical aeration is that ring the use of white of egg. When beaten or ed the sticky glutinous white of egg forms a froth is almost permanent, due to the air which becomes gled in its substance. When added to a sponge re sufficient air is introduced to make the dough and spongy.

ical. There are two types of chemical aeration. In the first type a single chemical substance ed which decomposes on heating with the production s which causes the goods to rise during baking. bonate of soda (baking powder) and ammonium nate (vol or volly) are the two most important ical aerators of this type. In the second type of ical aerator an acid substance and an alkaline nate are used together as a baking powder. In the nce of water the acid and the alkaline carbonate ine together to form a salt, water and carbon le gas. The salt formed remains behind in the ds" while the steam and carbon dioxide cause to rise. The alkaline carbonate almost invariably is bicarbonate of soda. The acid substances used

include cream of tartar, tartaric acid, acid sulphat sodium and potassium, and acid ammonium, potass sodium and calcium phosphates.

BICARBONATE OF SODA (BAKING SODA) $NaHCO_3$. Bicarbonate of soda is a w powder prepared by the amm soda process from brine. W heated it easily decomposes into carbonate of soda (w ing soda), steam and carbon dioxide :—

$$2NaHCO_3 = Na_2CO_3 + H_2O + CO_2$$

When used in baked goods no aeration takes p until the goods are baked, when the above decomposi occurs. The steam and carbon dioxide produce aera while the sodium carbonate is left behind. The follow points should be noticed about its use. Only half carbon dioxide of bicarbonate of soda is liberated by h The washing soda left behind has an objectionable ta and if present in large quantities may produce unpleasan flavoured goods. The presence of large quantities carbonate of soda may also give yellow stains in the goo Neither of these disadvantages applies, of course, to go which possess a strong taste and colour of their own, e parkin, and in such cases, larger quantities of bicarbon of soda may be safely used.

AMMONIUM CARBONATE (VOL. VOLLY OR VOLATILE). This chemical is a substa with an acrid burning ta and an ammoniacal smell. heating, it very rapidly decomposes into ammonia, ste and carbon dioxide. All these products of decomposit are gaseous and assist in the aeration of goods contain ammonium carbonate. If the ammonium carbonate pure no solid residue would be left behind in the goods

$$2NH_4CO_3 = 2NH_3 + H_2O + CO_2.$$

Unfortunately ammonium carbonate is seldom pure a on keeping loses ammonia by slow decomposition w consequent loss of aerating power. Although a v quick and effective aerator, the ammonia formed ins the goods is a distinct disadvantage on account of

ionable smell and taste. For this reason its use fined to small articles from which the ammonia uickly escape.

G POWDERS. While there are many different types of baking powders they all t of a mixture of an acid substance and an alkaline nate which in the presence of water combine together m a salt, water and carbon dioxide :—

$$2HX. + M_2. CO_3 = 2MX + H_2O + CO_2.$$

d and alkaline carbonate give salt and water and n dioxide. Any acid will combine with any alkaline nate to give the above type of reaction but obviously l acids or alkaline carbonates are suitable for use aking powder. The following points must be taken onsideration in the choice of a suitable mixture : bstances used should preferably be white powders ; lt formed should be tasteless, non-poisonous and ce no discolouration of the goods : the action between cid and the alkaline carbonate should take place rately, slowly and evenly so as to allow time for ulation of the dough : finally the substances used l be cheap. Of all the alkaline carbonates, bicarbon- f soda best meets these requirements. It is pure, . non-deliquescent and contains a very large amount rbon dioxide, the whole of which is liberated by

Cream of tartar ($KHC_4H_4O_6$) is commonly regarded e best acid ingredient ; it is only very slightly le in cold water but easily soluble in hot water. result, the reaction with bicarbonate of soda takes only slowly in the cold and quickly when heated. ion is consequently only slight before the goods are l in the oven but rapid during baking. The salt d as residue, Rochelle salt ($NaKC_4H_4O_6$), is white as no effect upon the colour of the goods, and far being poisonous it has a mild purgative action is frequently made use of in medicines, e.g., seidlitz ers.

$$HC_4H_4O_6 + NaHCO_3 = NaKC_4H_4O_6 + H_2O + CO_2$$

of tartar. Bicarbonate of soda. Rochelle salt. Water Carbon dioxide.

It is important to remember that an acid substance
an alkali can only neutralise definite fixed amount
each other. The use of too much bicarbonate of s
or cream of tartar will be not only wasteful but
harmful. If the bicarbonate of soda is present in la
amounts than the cream of tartar can neutralise,
excess will be decomposed in the oven during bak
with, as already mentioned, the formation of wash
soda, with its objectionable taste and staining pow
Should too much cream of tartar be employed the ex
will remain undecomposed in the goods and give them
unpleasant sour taste. It is for these reasons that gr
care is needed in the mixing of the cream of tartar
bicarbonate of soda in correct proportions. Th
proportions are two parts of cream of tartar to one p
of bicarbonate of soda and such a combination is frequen
referred to as a 2 and 1 baking powder. These proporti
have been worked out empirically in actual practice
receive interesting confirmation from the theoreti
equation.

$$KHC_4H_4O_6 + NaHCO_3 = NaKC_4H_4O_6 + H_2O + C$$

The molecular weight of cream of tartar combines with
molecular weight of bicarbonate of soda.

$KHC_4H_4O_6 = 39 + 1 + 48 + 14 + 96 = 188$
$NaHCO_3 = 23 + 1 + 12 + 48 = 84$

Hence 188 parts by weight of cream of tartar combine with
parts by weight of bicarbonate of soda. These proportions work
at almost exactly $2\frac{1}{4}$ parts cream of tartar to 1 part bicarbonate
soda.

It will be quite obvious that a baking powder shou
be kept perfectly dry or interaction will take place betwe
the acid substance and the bicarbonate of soda wi
consequent loss of carbon dioxide and loss of "strength
For this reason baking powders should be kept in a clos
tin and not in loose paper packets. Commercial baki
powders frequently contain a third ingredient as
"filler." This is usually some form of starch such
rice starch or cornflour, the hygroscopic properties
which assist in keeping the mixture dry by absorbi
any moisture it may come into contact with, and thus
preventing loss of strength in keeping due to interacti

een the acid and the alkaline carbonate. The h also reduces the actual contact between the acid ance and the bicarbonate of soda so that the powder s" freely.

r some purposes a quicker acting baking powder is desirable than the 2 and 1 baking powder. An llent quick-acting baking powder can be made by a little tartaric acid along with the cream of tartar. fact that tartaric acid is very soluble in cold water es such a baking powder to aerate quickly in the cold re the goods are placed in the oven and also during ng because of the greater solubility of cream of tartar ot water than in cold.

oth tartaric acid and cream of tartar have the disad- age of being rather expensive and for this reason a ber of cream powders or cream substitutes are lable. These are usually mixtures of acid sulphate of um and potassium or acid phosphates of ammonium, assium, sodium or calcium with starch. The purpose he starch is to make the cream substitute equivalent in ity to cream of tartar so that the convenient propor- s of 2 parts acid substance to 1 part bicarbonate of a can still be used. Baking powders containing such stitutes do not give such good results as regards ume, colour or flavour.

efore concluding this section on baking powder it also be mentioned that acid substances of other types frequently present in the same recipe along with rbonate of soda. Among such substances may be tioned sour milk, treacle and vinegar, all of which tain acids which will combine with the bicarbonate of a and liberate carbon dioxide for aeration purposes.

EXPERIMENTS ON BAKING POWDERS.

Experiment 1.

The action of heat on Bicarbonate of Soda (Baking Soda).

eat a small quantity of bicarbonate of soda in a test-tube fitted a cork and delivery tube passing into a second test-tube aining lime water. Notice the evolution of gas and the fact the lime water is turned milky. The gas is carbon dioxide.

When no further evolution of gas takes place allow to cool and a little dilute hydrochloric acid to the residue. Notice a fur evolution of carbon dioxide due to the decomposition of the sod carbonate formed from the bicarbonate of soda by the action heat.

$$2\ NaHCO_3 = Na_2CO_3 + H_2O + CO_2$$
$$Na_2CO_3 + 2HCl. = 2NaCl + H_2O + CO_2$$

Experiment 2.

The action of heat on Ammonium Carbonate (Volatile or Volly

Heat a small quantity of ammonium carbonate as in Experimer and notice that carbon dioxide is again evolved. Remove delivery tube and test for ammonia gas by smell and moist litmus. Place some carbonate in a crucible. Notice whether a residue of impurity undecomposed after prolonged heating is behind.

Experiment 3.

To examine the properties of Tartaric Acid.

(*a*) Examine a sample of tartaric acid and report upon its appea ance, taste and smell. (*b*) Add a little tartaric acid to water in test-tube, shake and warm. Notice whether tartaric acid is ve soluble or only slightly soluble. Test the solution with blue litmu Notice the effect. (*c*) Add tartaric acid solution to bicarbonate soda in an evaporating basin until no further effervescence tak place. Evaporate the liquid to crystallisation and obtain a samp of sodium tartrate crystals. (*d*) Repeat the previous experiment a flask fitted with a delivery tube passing into lime-water. No that the gas evolved is carbon dioxide. (*e*) Heat a little tartar acid in an iron spoon. Note changes in colour and smell any fume evolved.

Experiment 4.

To examine the properties of Cream of Tartar.

Repeat with cream of tartar the experiments already carried ou with tartaric acid. Notice particularly the respects in which th two substances differ.

Examine samples of Rochelle salt and tartrate of soda as i Experiments 3 and 4.

Experiment 5.

To prepare a Seidlitz Powder.

(*a*) **Alkaline Powder.** Weigh out 7·77 grams of Rochelle salt and 2·59 gms. of sodium bicarbonate. Mix the two thoroughly.

(*b*) **Acid Powder.** Weigh out 2·46 gms of tartaric acid. Dissolv the alkaline powder in water in a beaker and add the acid powder Notice the effect. Explain.

Experiment 6.

To prepare a Cream of Tartar Baking Powder.

igh out 13·36 gms. of bicarbonate of soda, 29·93 gms. of cream tar and 6·71 gms. of cornflour starch. Mix the dry ingredients ier very thoroughly.

Experiment 7.

To prepare a Combination Tartrate Baking Powder.

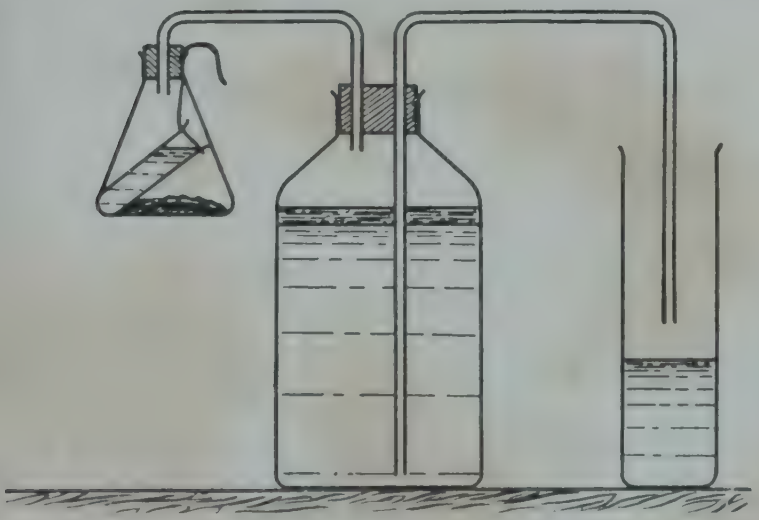
igh out 13·36 gms. of bicarbonate of soda, 22·45 gms. of cream rtar, 2·98 gms. of tartaric acid and 11·20 gms. of cornflour n. Mix the ingredients together very thoroughly. Add equal tities of each type of baking powder to (*a*) cold water ; (*b*) hot r. Draw conclusions as to the type of goods for which each is ble,

Experiment 8.

etermine the percentage of available Carbon Dioxide in a sample of Baking Powder.

By Volume.

t up the apparatus illustrated in the diagram. Weigh out about s. of a commercial baking powder and place in the small flask. a pipette measure out the 25 ccs. of water and place it in a l test-tube. By means of a thread lower the test-tube into the without spilling any water. Attach the flask to the rest of apparatus and shake the flask. The water comes in contact



34. Diagram of apparatus for determination of volume of available carbon dioxide of baking powder.

with the baking powder and the available carbon dioxide is libera
This displaces air which in its turn displaces an equal volum
paraffin, which is collected in a beaker. The volume of paraf
measured in a measuring jar. This gives the volume of avail
carbon dioxide from a known weight of baking powder and
percentage can be calculated.

The experiment may be repeated with a sample of your
baking powder and its quality compared with that of the commer
product.

(*b*) **By Weight** (Approximate Method).

The apparatus consists of a small dry flask containing a sm
test-tube nearly full of water which is held in position by a thr
passing through the rubber stopper. The stopper is fitted wit
calcium chloride tube and a glass tube at the end of which is fi
a rubber tube and clip.

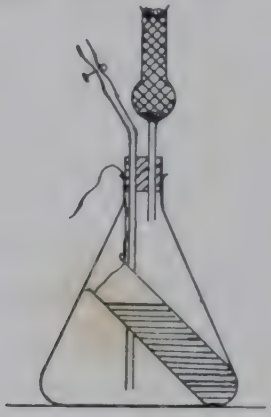


FIG. 35. Diagram of apparatus for determination of weight
available carbon dioxide of baking powder.

The flask and its attachments are first of all carefully weighe
About 2 gms. of baking powder are then introduced and the appar
tus again weighed. The increase in weight gives the weight
baking powder added. The flask is now tilted and shaken so as
bring the water and baking powder into contact. When no furth
effervescence takes place the flask is gently warmed by placing
boiling water. Why is this necessary ? Finally the clip is remove
and air either blown through the apparatus with foot bellows
drawn through by suction pump. Why ? The whole apparatus
now weighed, and the percentage loss in weight calculated.
good sample of baking powder should give at least 10 per cen
available carbon dioxide by weight. Your own baking powd
should be compared by this method. It is interesting to find th
corresponding percentages by volume and compare them with thos
obtained in the previous experiment.

(N.B.—44 gms. of CO_2 measure 22·4 litres at N.T.P.)

Experiment 9.

o carry out a Simple Analysis of a Baking Powder.

The Filler.

e a little of the baking powder in water and when effer-ce ceases place a little of the residue on a microscope slide by of a glass rod and examine under the microscope. It should ssible to recognise the particular type of starch used as a rom the shape and size of the starch cells.

The Acid.

Tartaric acid.—Shake a small sample of the baking powder absolute alcohol. Filter. Test the filtrate with blue litmus Tartaric acid is soluble in alcohol and if present will turn ue litmus red.

Cream of Tartar.—Shake with a little sodium carbonate on, filter. Add dilute acetic acid until the filtrate is just acid. well. If a white crystalline precipitate slowly forms on ing, cream of tartar is present.

Acid Phosphate.—Shake with nitric acid. Filter and add e filtrate a slight excess of ammonium molybdate. A canary w precipitate on warming indicates the presence of phosphates.

Alum.—Shake up a little baking powder with water until escence ceases. Filter. To the filtrate add a few drops of ire of logwood and then a few drops of ammonium carbonate ion. A blue colour indicates the presence of alum.

Experiment 10.

To test whether a Baking Powder has been correctly mixed.

Qualitative.

ce about 2 gms. of baking powder in a beaker with water. n effervescence has ceased, boil the mixture for a few minutes add litmus. If acid, see how many drops of dilute caustic (N/10) or, if alkaline, how many drops of dilute hydrochloric (N/10) are necessary to make the solution neutral.

Quantitative.

e previous experiment will almost certainly show that it is the m bicarbonate which is in excess. If an estimate of the tity of excess sodium bicarbonate is required it may be obtained her of the following ways :—

Repeat Experiment 8 (*b*) using dilute hydrochloric acid in of water. This will give the percentage of *total* carbon dioxide the use of water gives the percentage of *available* carbon de. It will be found that the total carbon dioxide is greater the available carbon dioxide for the following reason. When s acid is present the whole of the sodium bicarbonate is decom-l and the whole of the carbon dioxide liberated (*Total carbon de*). When excess sodium bicarbonate is present, carbon

dioxide is liberated due to interaction between the acid and equivalent amount of sodium bicarbonate and when the mixture heated the slight excess of sodium bicarbonate is decomposed sodium carbonate with the liberation of half its carbon dioxide (*Available carbon dioxide*). Thus the difference between the t and the available carbon dioxide gives the carbon dioxide equiva to *half* the excess sodium bicarbonate. From the relationship

44 gms. or 22·4 litres at N.T.P. are obtained from 84 gms sodium bicarbonate, the excess can be determined.

(ii) Weigh out accurately about 2 gms. of the baking powder place in a 200 ccs. graduated flask. Add water, shake and w effervescence has ceased dilute the solution to 200 ccs. Allow stand until the starch has settled to the bottom and then filter. 50 ccs. of the filtrate add a few drops of litmus solution and boil a few minutes to expel any dissolved carbon dioxide. Fina titrate the boiling solution with N/20 HCl or N/20 H_2SO_4. Fr the fact that 1 cc. N/20 acid is equivalent to 0·0042 gm. of sodi bicarbonate the excess can be calculated. It should be noted t although the bicarbonate is converted into the carbonate during boiling, this makes no difference to either the amount of a required for neutralisation or the method of calculating the result

Experiment 11.

Calculation of the quantity of Sodium Bicarbonate in a Baki Powder.

This is calculated from the total carbon dioxide as determined Experiment 10.

$$\text{Percentage total carbon dioxide} \times \frac{84}{44} = \% \ NaHCO_3$$

(Since 84 gms. of $NaHCO_3$ contain 44 gms. of CO_2 which c be liberated by acids.)

Experiment 12.

To determine the percentage of 'Filler' in a Baking Powder.

Weigh out accurately about 1 gm. of the baking powder and pla in a large beaker. Add to the baking powder about 200 ccs. hydrochloric acid of about 3 per cent. strength. Stir together ar leave to stand for at least 24 hours. At the end of this time filt the mixture through a filter paper which has been previously dri to a constant weight in the steam oven. Transfer the whole of th residue from the beaker to the filter paper and wash with distille water. Finally carefully transfer the paper to the steam oven eith in the filter funnel or evaporating basin and dry to a consta weight. Work out the percentage of dry "filler" in the bakin powder from the weighings obtained.

Experiment 13.

o examine Self-Raising Flours, Cake and Sponge Mixtures.

raising flours consist of flour to which is added the necessary ts of aerating materials. Their method of analysis is al with that of baking powders, except that, of course, the rtions of aerating agents being much smaller, larger quantities sample must be taken for analysis, e.g., 10 gms. instead of gms. used in the case of baking powders.

same remarks apply to cake and sponge-mixtures which t of flour, aerating agents, flavouring and colouring materials. rating agents used can be identified in the same way as these -raising flours.

YEAST AND FERMENTATION.

asts are unicellular fungi of a special group closely l to the Ascomycetes, which live saprophytically, is on dead or prepared organic substances, in their solutions or syrups of simple sugars. They decom- or ferment some of the hexose sugars, most readily ose, into ethyl alcohol (C_2H_5OH) and carbon dioxide.

$$C_6H_{12}O_6 = 2C_2H_5OH + 2CO_2$$

his way yeast converts grape juice into wine, apple into cider, and wort, or extract of malt, into beer, plays an essential role in the baking of bread where carbon dioxide evolved aerates the dough which equent heating fixes.

ne yeast plant is a microscopic organism consisting of gle round or oval cell, which on the average is from to three thousandths of an inch across : the size of cell varies somewhat with the species or variety of t. Each cell is bounded by a transparent wall of a ety of cellulose, and consists of protoplasm character- by the possession of a well marked and comparatively vacuole, associated with a granular network of matin—the nuclear apparatus. When conditions of are favourable the yeast cell increases rapidly by a le process of budding (gemmation). Such conditions a satisfactory temperature between 48° F and 95° F., fficient supply of food material in solution, comprising

sugars, proteins and such mineral salts as phosphat potassium, magnesium and calcium, and a suppl oxygen. When conditions are unsuitable, and there risk of the yeast plant dying from lack of food or moist as on a slice of potato or block of gypsum, reproducti

FIG. 36. Yeast cells, showing nuclear vacuoles and budding.

by way of spore formation. The yeast cell then becon spherical and its protoplasm collects equally in fo spherical spores, each surrounded by a protective wa The spores can survive a period of starvation, drough heat or cold, and are easily dispersed in the atmosphe by chance to spots where conditions are more favourab when they pass into the ordinary form of yeast plant a quickly start up fermentation in any sugar medium ava able to them. Yeast spores can withstand a temperatu up to 140 F., or even higher if dried.

The yeast plant decomposes glucose into alcohol a carbon dioxide without the incorporation of either oxyg

ter, and with the liberation of proportionately large
nts of energy, mainly as heat. It was once thought
his process of fermentation was a form of anaerobic
ation—that is without the intake of free oxygen—in
the energy required for the rapid production of new
substance in the largely increased numbers of cells
iberated from the food substances provided by the
m that was being fermented. Apart from the fact
in ordinary fermentation a small part only of the
used up—between one and two per cent.—fully
s to maintain the growth and increase of numbers
yeast, the remainder being largely converted into
ol and carbon dioxide, there is the further fact that
ecomposition of the sugar is brought about more
diately by an enzyme, zymase, which is secreted
e yeast protoplasm and can operate with undimin-
power when pressed out from the yeast cells and
d free from any trace of solid substance. Fermenta-
by yeast is therefore practically on all fours with the
n of ordinary enzymes, except that no other substance
the sugar takes part in the conversion. In addition
e main products, alcohol and carbon dioxide, there
small quantities of secondary products, chiefly
rol and succinic acid, as well as traces of alcohols
r than ethyl alcohol.

hen fermentation takes place in an abundance of
en, as when the liquid is well aerated, the yeast cells
iply very rapidly and little alcohol and carbon
de are formed, and these slowly. This fact is the
of the method now employed for making yeast on a
and industrial scale where it is the main product,
alcohol a waste product.

hen ordinary yeast is found to bring about the
entation of polysaccharides as starch and gum, or of
charides as malt sugar, cane sugar and milk sugar,
must first be hydrolysed to the hexose sugars by
r enzymes than the zymase secreted by the yeast,
as diastase, maltase, sucrase or lactase, as the case
be.

Many species, varieties and strains of yeast are distinguished only by their microscopic appearance and formation of spores, also by their fermentation products in the making of wines, b and spirits and in the baking of bread. Industrially yeasts classified as culture yeasts and as wild or disease-causing ye The former are employed in the fermentation industries, the la are abundant in the atmosphere during summer and autumn on the skins of fruits. In the baking industry yeasts are rou divided into the top yeasts and the bottom yeasts of the cul group; they all belong to the same species, Saccharomyces c visiae, but the two varieties are distinct and are not transform the one into the other. The bottom yeasts vary widely in size appearance and in their behaviour towards sugar solution. T ferment worts best at comparatively low temperatures betw 38° and 52° F. and are consequently used for the manufacture lager. The top yeasts alone are suitable for modern breadmak and are derived from the creamy froth on the top of the ferment liquors of the brewery and the distillery. Brewers' yeast formerly much used in home baking, but is now considered suitable because of the bitter flavour and aroma derived from ho Such yeasts ferment at a slow speed between 51° F. and 75° F. form a loaf dark in colour and faintly bitter in flavour as co pared with a loaf made with distillery yeast.

Distillery yeasts now most generally used in baking as "co pressed" or "German yeast" are manufactured either as a b product of the distillery or increasingly as a primary produ Malted barley is fermented at about 140° F. to hydrolyse the star of the endosperm to malt sugar. A high production of lactic ac is also ensured by the addition of a 'starter' consisting of a pu culture of a lactic bacillus. The original thick paste changes to thin liquid mash, or wort, which is drained off, filtered and cool to 72—75°F. A pure culture of the selected strain of top yea which has meantime been prepared in a separate small vat, is add to large quantities of the hydrolysed and acidified wort or oth suitable saccharine solution. Alcoholic fermentation follows ar the yeast multiplies abundantly. The amount of alcohol form is very much reduced and without any diminution in the repr ductivity of the yeast by a vigorous aeration of the fermenti liquor. As fermentation proceeds the froth of yeast is skimm off repeatedly from the surface. The yeast is separated from th liquor by centrifugalisation, repeatedly washed with water ar finally filter-pressed into cakes.

Cold storage is necessary for compressed yeast; othe wise it will liquefy by autolysis or self-digestion, due t the liberation of enzymes, and develop the growth c moulds and bacteria. Bakers yeast should contain a fe lactic bacteria but putrefactive bacteria should be absen When Bacillus mesentericus vulgaris is present it ma

ropy bread, particularly in warm damp air. Most diseases are checked by the presence of lactic acid ted by the accompanying lactic bacteria.

ast being a living organism is notably rich in protein hat in a readily assimilable form. When heated to a ular temperature yeast caramelises and forms a y extract ; in this form it may be used as a substitute eat extract (viz. Marmite). The preparation of from sawdust, starch and similar substances is the best method of producing protein from inorganic gen. Its richness in vitamin B complex makes and its processed products convenient and cheap ctive food substances.

EXPERIMENTAL WORK ON YEAST.

Experiment 1.

To examine samples of Yeast.

tain samples of fresh and old distillery yeast and subject them general examination noting particularly details of colour, smell, moisture and fracture. What conclusions can be h as to the quality of a sample of yeast from such preliminary ination ?

Experiment 2.

To examine samples of yeast microscopically.

ake up a small quantity of each sample of yeast with pure e water in a clean test-tube and by means of a sterilised glass lace a drop of the mixture on a microscope slide and cover a cover glass. Examine each in turn under the low and high rs of the microscope. Note the following points :—regularity riation in the size of cells, the strength and clearness of the alls and the presence or absence of vacuoles, buds and foreign isms. To detect the presence of very weak and dead yeast bring a small drop of methylene blue to the edge of the cover and allow it to spread underneath for a few minutes. Then ine the sample again microscopically. Very weak cells will re or less stained ; dead cells will be completely blue and active hy cells will be unaffected.

Experiment 3.

To identify the products formed when yeast ferments a solution of a sugar.

solve 10 gms. of grape sugar in 200 ccs. of water, cool the sol- to below 40° C. (Why ?) and pour into a large flask. Add

about 1 oz. of brewers' yeast. Fit the flask with a tight-fi rubber stopper and delivery tube dipping into lime water. P the apparatus in a warm place. Notice that after a short bubbles of gas appear and the lime water is turned milky. of the products of fermentation is carbon dioxide. Leave the paratus for at least 24 hours and then pour some of the liquid in small flask fitted with an upright tube. On gently warming liquid, the alcohol vaporises first and can be ignited. Any portion may be distilled and the first portion to pass over will so at 78° C., showing it to be alcohol. Notice the appearance smell of the distillate and see if it is inflammable. As a furt proof of identity the iodoform test may be carried out as follo To a small quantity of the distillate add a little iodine solution a few drops of caustic soda solution. On warming the mixt crystals of iodoform will separate, and can be readily recognised their shape and peculiar unpleasant smell.

Experiment 4.

To show that monosaccharides are more easily fermented by ye than disaccharides

Prepare solutions of cane sugar and glucose by dissolving 5 g of each in 100 ccs. of water. Place the solutions in flasks of eq size and add 5 gms. of the same sample of yeast to each. Wa each flask to 30° C. and fit with a delivery tube. Place the ends the delivery tube under inverted measuring jars filled with wa in a trough of water. Notice in which case bubbles of carb

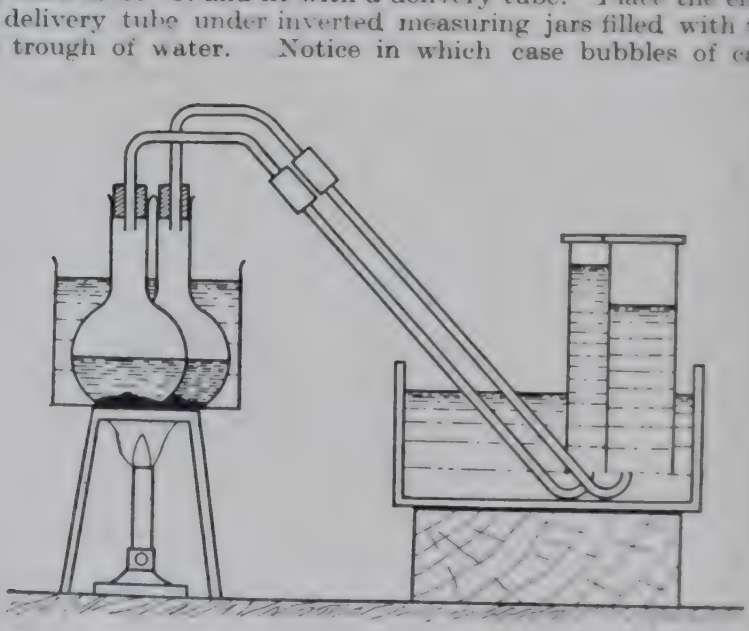


FIG. 37. Diagram of apparatus for comparing the gas evolvi powers of yeasts.

are evolved first and measure the volumes of gas in the ing cylinders at intervals of fifteen minutes. What is the ation of the differences noted ?

Experiment 5.

compare the gas evolving powers of two samples of yeast.

gh out accurately 5 gms. of each of the two samples of yeast. he samples in 250 ccs. flasks and add 10 gms. of cane sugar n. Add 100 ccs. of water at 30° C. to each flask and quickly h with a tight fitting rubber stopper and delivery tube. the flasks in a water bath at 30° C. with the delivery tubes inverted measuring cylinders in a trough of water (see diagram). the time taken for each sample of yeast to begin evolution bon dioxide, and subsequently record the volumes of carbon- e evolved at 15 minute intervals.

Experiment 6*.

To compare the qualities of two samples of yeast by the cylinder test.

measurement of the gas evolving power of yeast by the pre- method is liable to yield inaccurate results in inexperienced and should be confirmed by the following cylinder test. rs are made of 20 gms. of flour, 30 ccs. of water at 30° C. and s. of each of the samples of yeast. These are then placed in r 250 ccs. measuring jars and left in a warm place at as nearly ssible the same temperature. The levels of the batters in each der should be recorded at intervals of 5 minutes as well as the taken for each batter to rise to its highest point and the h of time before the batter drops.

nentation. Fermentation methods of aeration of dough are those involving the use of t. When mixed with dough in breadmaking yeast itself in the presence of an ample food supply at a ble temperature and under these conditions its mes act upon the food materials present in the dough fermentation takes place. The enzymes maltase and rtase change the disaccharide sugars of dough into se sugars which the enzyme zymase breaks up into l alcohol and carbon dioxide. In addition small unts of succinic acid, acetic acid and glycerol are ed as by-products. A change also take place in the eins of the dough. The soluble proteins are in part erted into peptones and amino-acids which, along the mineral salts of dough, are utilised by the yeast

for its nourishment and growth. These changes hav distinct effect upon the flavour and digestibility of resulting bread which is absent from mechanical chemical methods of aeration.

Baking of Bread. It is proposed here to discuss the met used in home breadmaking. While differs in details from that used in large s commercial work the underlying principles are essenti the same.

The primary ingredients of bread are flour, ye water and salt; other ingredients are occasiona employed according to the type of bread desired, such fresh or sour milk, fat, malt extract, yeast salts, wh germs and aerating chemicals. The making of bread fr the first four ingredients will be now briefly described.

The flour is first of all weighed out and transferred an earthenware bowl which has been previously warm The salt is next mixed thoroughly into the flour to preve direct contact of salt with yeast. Three and a half pour of flour require three teaspoonfuls to produce the necessa flavour and stabilisation of the gluten. The necessa amount of yeast is now weighed out (1 oz. for 3½ lbs. flour) and mixed with warm water to which a little ca sugar may be added. The use of warm water is necessa to make the yeast more active. The actual temperatu of the water used will vary with the temperature of t flour and the temperature of the room. The object is produce a dough temperature of about 80° F. (27° C.) which temperature fermentation takes place most rapidl Generally speaking the temperature of the water us should be between 90° F. and 100° F. (blood heat or mi warm). A hollow is next made in the flour, into whi the mixture of yeast and warm water is then added un sufficient is used to convert the flour into dough. T dough is then thoroughly kneaded to ensure an intima mixing of all the ingredients and thorough absorption water by the gluten. The bowl is then covered with cloth to prevent contact with draughts and conseque chilling of the yeast, and placed in front of the fire to ri

rove '—to use the technical term. The dough has
ly risen to about double its original bulk in roughly
nd a half hours. It is then turned on a board
ously dusted with dry flour to prevent the dough
ng to the boards or hands, and divided into portions
e proper weight to make loaves of the desired size.
process is technically known as " scaling " ; ordinarily
3 ozs. of dough is necessary to produce a 2 lb. loaf.
piece of dough is moulded into the required shape,
f placed into tins these should be greased and about
filled. The scaling should be carried out before the
h is over-fermented or oven-ripe, and should not be
ed out roughly because of the distended condition of
ough, and the strain put upon the gluten. The dough
ain lightly kneaded to bring the yeast cells into contact
fresh food supplies and again placed before the fire to
further. This second proving gives the dough a
ce to recover from the scaling which no matter how
fully it is carried out results in some loss of gas and
ping of the dough. When the dough has risen
ciently the loaves are transferred to the oven. After
ng the bread is withdrawn and allowed to cool.

e will now consider in greater detail the various intimate
ges that take place in the baking of ordinary bread from flour,
, water and salt.

e components of the flour of importance in baking are starch,
n, mineral salts and enzymes. When starch is mixed with
r and heated to about 60° C. it absorbs water and gelatinizes,
ming colloidal, and expanding bursts the granules. It might
nought, since the baking temperature of an oven is anything
een 200° C. and 240° C. and the amount of water in ordinary
h exceeds 40 per cent., that most of the starch within the
would be gelatinized and the granules burst. As a matter of
the granules even after long baking, will show a mixture of
still unchanged by the damp heat, of those slightly swollen,
of comparatively few completely gelatinized. The reason is
the temperature inside a loaf seldom exceeds 95° C. and this
short time only, and perhaps also, in view of the great affinity
ten for water, there is an insufficiency of water for the purpose
ll gelatinization of the starch.

e starch granules in the flour have usually been slightly acted
by the diastase of the germ and converted into maltose, or
sugar. When therefore the flour is mixed with water and yeast
is sufficient sugar for the yeast to start fermentation. The

maltose is converted by the specific ferment maltase into de
or glucose, and the sucrose if present by another ferment
tase into dextrose and fructose, and it is upon these hexose
the zymase secreted by the yeast operates, converting them
roughly equivalent quantities of carbon dioxide and or
ethyl alcohol.

This change is not such a simple one, for other products
such as succinic acid, acetic acid and glycerol in small amoun
well as lactic, acetic and butyric acids formed by lactic, aceti
butyric bacteria, which may be present in the yeast, or in m
this is used in baking, the moderate growth of which improve
flavour of the bread. The mineral salts in the flour are mad
of by the yeast and are essential to its healthy development.
addition of other mineral salts, such as ammonium persulpha
potassium bromate, stimulates yeast growth enormously, a
therefore often practised industrially.

Changes take place also in the gluten of the flour. Flour gl
is a mixture of several proteins, chiefly glutamin, gliadin, glo
and coagulated albumin, and soluble forms found in water wash
During the fermentation of the dough, the soluble proteins
converted by proteolytic enzymes secreted by the yeast cells
peptones and a similar change takes place in the insoluble prot
This partial change from insoluble gluten to soluble compound
accompanied by a noticeable difference in the 'feel' of the do
This maturation of the gluten is assisted by the increasing aci
the dough as a result of the by-products of the alcoh
fermentation.

In the rising or 'proving' of the dough the carbon dioxide
produced by alcoholic fermentation distends the dough, whic
tenacious and elastic because of the gluten having taken up m
water and become gelatinous or colloidal. Wheat is the only g
giving a flour containing gluten sufficient and elastic enough w
matured to hold the abundant gas bubbles generated by the ye
Oatmeal forms a biscuit-like bread as Scotch bannock and Yorksh
havercake.

The character of gluten, upon which the baking qualities
strength of flour largely depend, is intimately connected with
action of mineral salts upon colloids generally. Gluten is a coll
and a mixture of several different proteins, and changes in
hydrogen ion concentration of such a mixture have often mark
effects. Such changes may seriously modify the colloidal nat
of the proteins which plays a primary role in breadmaking. T
addition of salts of trivalent ions such as $Al^{\cdots}$ and $PO_4^{\cdots}$ has
considerable effect. The addition of alum, now illegal, harde
and coagulates bad and low grade gluten, making available old
damp flour in which the gluten has deteriorated under the act
of lactic or other bacteria.

Particular improvers play another part, affecting the pH val
of the dough bringing it to a point best suited to the activity of t

rganism necessary for its activity and growth. Suitable
l improvers are ammonium persulphite, acid calcium phos-
id potassium bromate ; This latter has proved particularly
in higher grade or ' strong ' flours with good gluten.

ineral contents of the water used in breadmaking are of
nportance in securing the finer degrees of quality. The
d salts affect the gelatinization of both starch and gluten,
the rate of development of the yeast, which as a living
n needs a wide variety of food minerals. Pure distilled
nakes a dough that is sticky rather than springy. Soft
water destroys the springiness of gluten by the disintegra-
its particles. " Hard " water, especially when containing
es, as gypsum, hardens the gluten. Chlorides, and in par-
common salt, to a point materially help gluten in its absorp-
d retention of water, and therefore play an important
ts maturation, as well as in moderating the activity of yeast.

n placed in the oven the transformation from dough into
akes place. The normal temperature for white bread is
0° C., and the time for baking about 50 minutes. The changes
ake place in baking are many and various. For the first
nutes in the oven the higher temperature results in increased
ctivity with a consequent increase in loaf size (" oven spring")
fter 10-15 minutes the temperature reaches about 60° C.,
he yeast cells, bacteria and enzymes are all destroyed. No
fermentation can take place and the loaf is sterilised. The
bbles are also expanded by the heat and the gluten coagulates,
the shape of the loaf. The alcohol is almost entirely driven
t small quantities of the volatile esters and lactic acid remain
ve the bread its characteristic flavour. While the tempera-
the middle of the loaf never reaches boiling point, the out-
ecomes much hotter, with consequent drying and the forma-
f a crust. The crust is altered in composition, becoming
ly caramelised with the formation of dextrin and sugars,
not only give it its colour and flavour but make it, equally
past, more soluble, appetising and digestible.

n withdrawn, the baked loaves cool, and the solid crust
cts with the formation of small cracks through which hot
rs can escape from within the loaf.

bread is due not, as is often thought, to lactic acid but to
e acid formed by a butyric fermentation subsequent to lactic
rmation. Ropy bread is due to the growth within the bread
rticular bacterium, B. mesentericus, made possible by changes
acidity of the bread and the establishment of suitable con-
s of temperature and moisture.

-rising bread is made by bacterial fermentation. Maize
s soaked with hot milk and allowed to ferment. Since the
s almost at boiling point, only spore forms are present, most
yeasts and undesirable bacteria having been destroyed.

The spores on germination produce bacteria which form g
interaction with the milk sugar and starch of the paste.
plays little or no part in making the bread.

While ordinary bread is made simply from flour, y
water and salt, home-made bread is commonly made
the addition of small quantities of milk to the
mixture, or of lard or other fats rubbed in dry wit
flour. Even in small quantities these have a consider
influence on the appearance, flavour and particularly
keeping qualities of the bread. Where a simply made
will be stale in two or three days, a milk- or fat-made
remains palatable and fresh for over a week.
probable that the reason for this difference is that w
fat and other milk ingredients are everywhere fi
distributed throughout the loaf as thin protective fi
they maintain the colloidal nature of the gluten and st
much longer than would be the case otherwise.
ordinary bread the colloidal substance, particularly not
able in new bread, rapidly undergoes disintegration :
is not simply a matter of losing water, for little is actu
lost, and the staleness can be readily removed by sim
placing the stale bread in a hot oven for a few minute

Food Value and Digestibility of Bread. Next to milk, bread is most complete food available human use, containing as it d protein, fat, carbohydrate and mineral ingredients. constituent in which it is normally most deficient is but this is usually compensated for by bread being ea with some form of fat, e.g., butter. The large amount carbohydrate makes it an excellent food to be eaten al with foods rich in fat and animal protein, for its protei not of the first grade.

Brown flour prepared by "high extraction" (80% 85%) of the wheat berry is more nutritious than "strai run" white flour (72%) for it contains appreciable amou of the outer layers of the grain, including the germ embryo, which contain vitamins of the B group, a minerals—calcium and iron—in higher concentrati than in the endosperm, which forms the greater part white flour. Wholemeal flour and National flour

better protective foods than ordinary peace-time flour. Experiments with rats have proved that d on wholemeal bread are in every way healthier hose fed on the white bread which has been the main of diet of the poorer sections of the British popula- being free from infection, sturdier, more fertile and lived. The introduction, as a matter of absolute ity, of high extraction flour during the world war than economising shipping space ensured, it is d, a higher general fitness of the civilian population. nprovement was put down largely to the credit of tamins B_1, Riboflavin and Nicotinic acid, which are ial to growth in the young and to high nervous tone bodily functions in both young and adult.

re is one drawback, however, in the use of the darker ed flour with its admixture of the chaffy particles husks, other than that often ascribed to it as causing psia, that due to the presence of phytin which rs the absorption of calcium and iron. In order to t the possible serious loss to individual consumers of m, which is so necessary in the building of bone, enance of nervous tone, and the clotting of blood, linistry of Food ordered the addition of 7 ounces of red chalk to every 280-pound sack of flour, so en- g an average daily intake of 1 gram, which is now d to be the safe minimum.

Average Composition of Bread (per oz.).

	Protein *g.*	Fat *g.*	Carbo-Hydrate *g.*	Calcium *mg.*	Iron *mg.*	Vit. B1 *mg.*	Riboflavin *mg.*	Nicotinic Acid *mg.*	Vit. A C & D
72% ction nal,	2·3	0·2	15·6	4	0·2	0·01	0·01	0·2	Nil
ction meal	2·4	0·4	14·6	16*	0·5	0·05	0·03	0·3	Nil
ction	3·1	0·6	11·2	7*	0·7	0·09	0·05	0·6	Nil

* After addition of chalk to the flour.

CHAPTER XV.

MILK.

Milk is the creamy yellow liquid formed by all fe
mammals for feeding their young. Cow's milk is the
most commonly used and is regarded as Nature's
perfect food. It contains every type of food mate
protein, carbohydrate, fat, mineral salts, water and
vitamins. For infants milk is by nature a complete f
but for adults as well as for children there is too m
water in milk for it to be used as the sole article of
It is not only valuable by itself but it greatly increases
food value of cereals and bread when these are mi
with it instead of water. It should always be remembe
that milk is a food and not merely a beverage.

The colour of milk is due to tiny globules of fat, ti
by a pigment lipochrome, which are dispersed through
the water portion of the milk as an emulsion. W
milk is allowed to stand these globules of fat, being ligh
than the rest of the milk, rise to the surface of the
and form a layer of cream. When this cream is remo
by skimming or by a separator the remaining portio
known as "skimmed milk" or "separated milk." T
skimmed or separated milk contains all the dissolved f
materials of milk and is a valuable article of food w
many uses.

If milk is allowed to stand for a few days it separa
out into two different parts—a coagulation at the surf
known as "curd" and a watery liquid underne
known as "whey." This change is brought about
lactic bacteria which feed upon the sugar in milk (lacto
and change it into an acid (lactic acid), wh
then curdles or coagulates the chief soluble protein
milk, caseinogen. Clotting, as distinct from curdli
is brought about by the addition of any other a
to milk; the caseinogen is then converted into case
The acids most commonly used are vinegar and len
juice. Coagulation of caseinogen as casein can also

t about by the rennet used by cheese-makers for g milk. This is an enzyme obtained from the division of a calf's stomach in which it is secreted gulate or curdle the milk which the calf drinks as its Junket is made by adding rennet in solution to milk at blood heat and then adding some flavouring al. The rennet is "killed" if heated beyond

specific gravity of good milk is between 1·028 and If cream is taken out of milk the specific gravity milk is raised. Measurement of the specific gravity as a rough test for the purity of milk by means of a eter. But it is possible to take cream out of milk y putting in water still to keep the specific gravity en 1·028 and 1·034. A lowering of the concentration milk sugar below the normal value indicates adultera- f this kind. The only absolutely reliable test is a emical analysis of the milk, but this is long and icated.

en milk is heated it easily "boils over." This is se the heat has coagulated another protein substance ved in milk known as lactalbumin, which forms a n the surface of the milk, and the collection of steam neath it causes the milk to "boil over." Caseinogen gulated by acids and rennet but not by heat.

osition k.

The composition of cow's milk varies somewhat with the breed of animal, the stage of lactation and the character of the whether it is hay and oil cake, or fresh pasture and this young or old, rich or poor in staple. On erage, good cow's milk as marketed has a composi- hich varies little from the following schedule :—

Composition of Cow's Milk.

		per cent.
Water		87·55
Protein... ...	3·40	Solids 12·45.
Fat	3·60	
Milk Sugar ...	4·70	
Ash	0·71	

Human milk differs from cows' milk most evident two respects; it contains more milk sugar, and protein, which is decidedly richer in lactalbumin tha caseinogen—the former of marked higher biological v Accordingly when cows' milk is used for the rearin infants it is usually diluted with water, and a little su preferably milk sugar, or glucose added to it, but wit correcting for the difference in kind of the proteins.

Composition of Human Milk.

		per cent.
Water		87·40
Protein... ...	2·29	
Fat	3·81	Solids 12·60
Milk Sugar ...	6·20	
Ash	0·30	

Constitution of Cow's Milk.

Milk Proteins.

These consist of two: caseinogen and lactalbumin, former totalling some 3 per cent. of the total milk and latter only 0·4 per cent. In contrast the percentages human milk are 0·5 and 1·7 respectively. *Caseinogen* i complex protein to which has been given the empiri formula $C_{560}H_{895}N_{1400}O_{170}S_3P_3$. It is closely associat with calcium compounds in the ash to form what is kno as calcium caseinogenate, a loose compound which easily hydrolysed by lactic acid to give calcium lacta and free caseinogen as a curd. Caseinogen when rubb with lime forms a colloidal suspension. The enzy rennet throws down a clot of casein in combination wi lime from which cheese and latterly many other industr products are prepared.

Heat does not coagulate calcium caseinogenate, b *lactalbumin*, which is much like egg and blood albumi coagulates at 70° C. As we have seen already it forms t film on the surface of hot milk. A third protein, *lac globulin*, is found in much smaller amounts, about 0·05 p cent., and like lactalbumin coagulates with heat.

Fats.

k fat separating as cream is a mixture of many fats, simple and others mixed glycerides of quite a long of fatty acids; beginning with butyric acid and g up to oleic acid, including also caproic acid, lic acid, lauric acid, myristic acid, palmitic acid, and c acid. The chief fatty acid is oleic acid, but the characteristic is butyric acid.

acid being unsaturated is liable to take up oxygen and give a variety of derivatives, some of which when decomposed cteria give substances with unpleasant odours and flavours. atural flavour of cream and its chief product butter is due to wer volatile acids and their esters, and not to the higher ers of the series. When freshly drawn the fatty globules are microscopical in dimensions ranging between 1×10^{-4} mm. $\cdot 2 \times 10^{-2}$ mm. in diameter. The fat globules have the pro- of adsorbing proteins out of their water solution to form of these on their surface, which function as continuous films tings, and tend to keep the globules from coalescing.

addition to ordinary fats milk contains small quantities of ther important substances, lecithin and cholesterol. *Lecithin* gs to the group of phosphatides. (See page 69). It is re- ly more abundant in human milk than in cow's milk, and ins one third its total phosphoric acid. When hydrolysed and ed during putrefaction lecithin gives tri-methylamine, $N(CH_3)_3$, causes a fishy odour in milk. *Cholesterol* varies between nts of 0·07 and 0·4 per cent. It is usually found in animal its isomer, phytosterol, is found in vegetable fats, and its nce in butter is taken as a sign of adulteration.

Sugar.

lk sugar or lactose is found is cow's milk in amount t 4·7 per cent., and more (6·2 per cent.) in human It may be recognised as a reducing sugar in milk has been both skimmed of cream and cleared of clotted by rennet. It is a disaccharide, and is olysed by the ferment lactase to form an equimolecular ure of glucose and galactose. When heated it melises—hence the flavour of milk puddings. It is ly acted upon by lactic acid organisms and yields acid, which makes butter milk and whey sour

MINERALS OF MILK.

The mineral elements represented in the final dried incinerated residue of whey are sodium, potassi calcium, magnesium and iron, as phosphates, chlori sulphates and carbonates. The abundance and av ability of the calcium salts and phosphates have further advantage of increasing the effect of any vitar D in other articles of food. The percentage of iron very low, and altogether inadequate to meet the needs a developing infant. Cow's milk is even more defici in iron than human milk; in the case of the you animal it can, however, eke out its supply by nibbl grass. Iron in some form or other should be added cow's milk, all the more when it is diluted as usua supplied to young children. For a while only, a you baby can draw on its own stores of iron in the liver.

MILK GASES. When freshly drawn, cow's milk contai gases to a volume of 10 per cent.; these are carb dioxide, oxygen and nitrogen.

VITAMINS IN MILK. Milk contains all the commonly r cognised vitamins; it is particular rich in Riboflavin, is a good but not wholly sufficie source of vitamins B_1 and C; milk fat is an excelle source of vitamin A and a variable source of D. Cow milk has received an extraordinary amount of attentio so far as its vitamin content goes, perhaps more so tha any other substance, and inevitably the assessmen of the values of the several vitamins by many observe throughout the world vary somewhat. It is now reco nised that the amounts of vitamins in milk vary not onl with the breed of the cow and its physiological state, bu also with the character of its food. The vitamins as whole, and particularly A and D, are higher in summe when cows are out to grass and in the sunshine, than i winter and early spring when they are kept in the byre on hay and oilcake. The composition of the herbag and its age, whether for instance, it is short and freshl grown or mature and fibrous among other factors, mater ally affect the vitamin content of the milk. The amoun

amin C in milk also varies as between the winter
e summer feeding and exposure of the cows. This
n is very appreciably diminished in value on heating
air, and on exposure to sunlight, as in dairy bottles.
is reason therefore a whole milk or partial milk diet
ng children should be compensated by reasonable
of fruit or vegetable juices rich in vitamin C, as in
fruits, turnips or swedes.

ge of Milk. Milk is not only a splendid food for animals and human beings but also for
ia. Some of the bacteria are harmless and turn
our, while others are disease germs, as of diphtheria,
id and tuberculosis. Every care should therefore
ken to prevent the entrance of bacteria, and patho-
organisms in particular, at every stage from the
o the consumer—in the farm, in transit by road or
delivery by the roundsman, and not least in storage
home. Too great care cannot possibly be taken in
ning clean milk and in keeping it meticulously clean
ghout, otherwise it may become positively dangerous.

e best milk is that which reaches the consumer as
y as possible in the state in which it leaves the cow's
. The odour, taste, keeping quality and health
of the milk depend entirely upon the bacterial
nt. Milk alters at first slowly and later rapidly;
y because it absorbs taints and odours from its
bourhood, and partly because of bacterial action.
great care is required if milk is to keep its normal
tion for any length of time.

cterial contamination of milk enters at various
s, which may be briefly indicated in order. (a) The
udder: even in healthy cows the milk produced is
bsolutely sterile; milk from diseased animals teems
bacteria and should never be used for human food
y kind. (b) The cow's body: where cattle are not
clean and groomed, and open pail milking is prac-
there is every opportunity for vast numbers of
-organisms to get into the milk. (c) The atmosphere

of the byre : dust is always full of micro-organ derived from the hay and fodder, dried dung, cob etc. (d) The milker : the utmost cleanliness of p and methods of milking, and the sterilisation of all ut are plainly indicated. When the transit from the producer to the consumer is short, as in the countr medium sized towns, the chance of contaminatio much reduced if the milk is in sealed bottles filled at dairy and deposited on the doorstep or window sill o consumer. In the vastly more considerable industr getting milk from thousands of farms over dozen counties, often many hundreds of miles from the centre of distribution, the chances of contamination now largely reduced by elaborate methods of sterilisa But all the care of the producers and transporters of may be easily brought to nought by the household she fails to observe reasonable precautions against posure to contamination. Milk should be kept cool the dark, and sealed. It should not be left for any le of time in open basins or jugs. In summer time t should be kept cool and protected from flies and dust close muslin covers—a single fly can carry several hund thousand bacteria. Milk should never be placed nea sink or any food substance with a strong odour.

The main types of micro-organisms found in milk are as follow

1. (a) True lactic bacteria—Streptococcus lacticus.
   (b) Bacillus coli communis and groups.
   These ferment milk sugar.
2. (a) Casein digesting bacteria.
   (b) Bacteria causing colour changes.
   These do not ferment milk sugar.
3. Pathogenic bacteria.
   (a) Accidentally introduced.
   As typhoid, diphtheria, etc.
   (b) Derived from the cow.
   As tuberculosis, cow-pox, etc.

Lactic bacteria, chiefly S. lacticus (B. lactic a grow best in milk at 25° C. giving about one per cent. lactic which is mild in taste and coagulates the milk, no whey form Bacillus coli communis and other groups ferment milk sugar give acids and gas. The milk so soured has an offensive od and a disagreeable taste. Acids, other than lactic acid are form

acetic and formic acids. The clot often encloses gas bubbles
me shrinks, and may be liquefied if any peptonising bacteria
ent. The presence of this group of bacteria indicates care-
tling. They are favoured by an appreciably higher temper-
0°-40° C.) than that suitable to lactic bacteria.

n-digesting bacteria give alkaline products with unpleasant
and flavours and are encouraged by the reduction of the
of ordinary sour milk. Quite a variety of bacteria produce
sion, often alarming changes in the colour of milk: generally
prodigiosus), but some blue (B. cyano-fluorescens); these
are seldom dangerous.

most serious pathogenic organism in milk derived from the
Bacillus tuberculosis, which, as a primary source of human
losis, it is incumbent upon all concerned to keep within
by every means possible. Although tuberculosis in adults
seldom due to infected milk, this is not the case with children.
ection may come from a tuberculous cow or be introduced
berculous person handling the milk. Fortunately the micro-
m does not multiply much in milk.

nisms accidentally introduced into milk include diphtheria,
and para-typhoid fever, dysentery, septic sore throat and
fever. Epidemic forms are generally due to some person
ed with the milk supply or the return of bottles from some
rson. Primary cases begin to gather along a particular
und and the epidemic of such dies down as suddenly as it
Unfortunately, many of this class of organism thrive in

f Spoilage of Milk.

fairly definite periods in the decomposition of milk may be
sed.

r the first four to six hours after milk is drawn, there is an
nt decrease in the number of micro-organisms, due probably
clumping of the bacteria. ii. The second period is that of
souring due to the enormous development of Streptococcus
s which makes 99 per cent of the total flora, by the time the
comes sour and curdles. Before the milk can curdle suffi-
ctic acid must be formed to react with the calcium casein-
to form calcium lactate, and thus little free acid is available
hile. The characteristic odour and taste of sour milk is not
lactic acid, but to the presence of undetermined volatile
nds. Such sour milk though spoiled for ordinary use, is in
ndition for cheese making. iii. When coagulation of the
has taken place, free lactic acid is in sufficient strength
1 per cent.) to stop the further development of the lactic
ms, and their numbers diminish more or less rapidly. Or-
s now develop, which have hitherto been dormant (Oidium
nd other moulds, and yeasts) and as they grow the acidity
ed until the proteolytic bacteria can grow, the milk becomes

alkaline and the final stage is reached. iv. In the fourth stag liquefying and peptonising bacteria rapidly decompose the va proteins and thus alkaline whey is formed with an unpleasant o

Abnormal fermentation of milk occasionally takes place, g ally as a result of insanitary dairy conditions. Bacillus coli comm produces disagreeable odours and flavours ; in the spore form very resistant to heat. One of the commonest forms of bac spoilage is ropy or slimy fermentation due to B. lactis viscos form resistant to heat and only removed from dairy utensil drastic scalding and disinfection. Bitter milk, due to bact changes, is occasionally met with in the cold storage of milk. Y very occasionally cause alcoholic fermentation of milk sugar.

Treatment of Milk. In these days when large quanti of milk are transported often c siderable distances from the producer to the consume many hours elapsing between drawing in the dairy a using in the home—it has become necessary to have long a period as is reasonable in which the milk will k sweet. It is further recognised that raw untreated m may be a medium for the transmission of infectio Various methods have been adopted with a view to inhi the growth of organisms, or to bring about a substant reduction in their numbers. Purely mechanical tre ment, such as straining milk through wire or cloth siev or centrifugalising it, with a view to the removal of t gross particles of dirt, and with them some proportion any rate of bacteria, fail in the main purpose of improvi the bacterial content of milk. In any case in any clea dairy practice there should be no dirt to remove.

Various chemical preservatives have been used, t chief among them are calcium hypochlorite, formal boric acid, borax, benzoic and salicylic acids, acid pot sium fluoride, hydrogen peroxide, sodium carbonate a bicarbonate. With the exception of soda, which simp neutralises the lactic acid when formed and stops curdli all retard souring by inhibiting the lactic organis without affecting the pathogenic bacteria. The use of such preservatives in milk and cream is now prohibit

It is by the use of certain temperatures that the life milk micro-organisms is best regulated. Very few c increase in numbers at 10° C. or below, even though no

m are destroyed. 10° C. is the most favourable rature for the storage of milk, for at this point tic bacteria can grow and produce lactic acid sufficito check the action of the proteolytic organisms. g milk as soon as drawn is both efficient and harms a method of preservation.

LISATION OF MILK. Milk may be preserved by sterilisation, for which two methods common use. In the first, the milk is generally genised and kept at boiling point for 30 to 60 minutes ans of steam. This kind of sterilised milk shows no line. In the other method, the milk is circulated pressure through narrow tubes in an atmosphere of at 130° C. By either process all bacteria except spore forms are destroyed, so that the milk may be sweet in cold storage for many weeks. The taste ood value however are altered.

EURISATION OF MILK. By far the commonest form of preservation of milk by treatment is pasteurisation, the object of which is estruction of the majority of the bacteria, including athogenic forms. The chief disadvantage attending method is that the temperature necessary may alter haracteristics of the milk. The recognised system sts in heating the milk to a temperature not lower 145° F. (62° C.) and not higher than 150° F. (65° C.), maintaining at this point for 30 minutes, after which cooled. To hold a large volume of milk, say of ,000 gallons in large plants within two or three es of a particular temperature for half an hour, nds the use of an apparatus, the thermal control of must be one of delicacy and exactitude. If any on of the liquid escapes being raised to the proper erature, or for long enough period, disease germs escape destruction and be afterwards free to develop. e temperature as a whole rises above the limit the line is changed, the lactalbumin is coagulated and nes insoluble, the vitamins may be destroyed and xcessive proportion of the lactic organisms are

destroyed, so that the milk does not sour normall keeping and the milk is liable to undesirable change immediately apparent to the consumer. The effici of industrial pasteurisation is very largely a matter o competent exercise of thermal and bacterial control. has been proved that the infections transmitted by mi tuberculosis, typhoid fever and diphtheria—are destr by efficient pasteurisation. Milk highly infected f tuberculous cows is rendered harmless by pasteurisa at 63° C. for 30 minutes and rapid cooling. A r efficiency of the method in commercial practice is all more necessary in view of the rapid development of transport in which the milk of a very large numbe cows, some 10 per cent. of which are likely to be tu culous, is mixed in road or rail tanks often 3,000 gal in capacity, so that the whole is infected.

The official grades of milk in use since June 1st, 1 are such as to emphasise the need for clean method drawing, transport and processing. They are as follows

"Tuberculin Tested Milk." This is produced by he proved free from tub culosis by the tuberculin tests every six months bottled and sealed immediately on the farm, the w "Certified" may be added to its designation. delivery the bacterial content is less than 200,000 per c and Bacillus coli is absent in 0·01 c.c.

"Accredited." The cows are to be tested w tuberculin before inclusion the herd and examined by the veterinary surgeon ev 3 months, defective cows being segregated. Such m contains less than 200,000 bacteria per c.c. and no B. in 0·01 c.c.

"Tuberculin Tested (Pasteurised)." This has to confo to the same re lations as "Tuberculin tested," and is heat trea once only. It must contain less than 30,000 bacte per c.c., and no B. coli in 0·01 c.c.

rised Milk. This term covers any "accredited" or ungraded milk which after one heat ent contains less than 100,000 bacteria per c.c.

chief significance of the totals of bacteria is that the g properties of milk depend on the bacterial con- hich is also a measure of the dirt present, and the aken throughout. By far the greater proportion k distributed in the largest centres of population commercial distributors is pasteurised ; in London 90-95 per cent. Compulsory pasteurisation if ished for all the larger urban areas would entail an nent possible only to large undertakings and the ation of the casual producer-retailer, who in time become the chief purveyor of a high grade raw lternative to pasteurised milk. It would appear ilk loses some of its nutrient qualities when pasteur- o that in the case of infants, at any rate, it requires menting as regards vitamins and salts. But for en and adults the bulk of whose nutritive require- of several kinds is satisfied from other sources, rised milk is as adequate as raw milk. The prob- cal risk that pasteurised milk, because of a deficiency ic organisms, is more liable than raw milk to infection much minimised by the use of sealed containers imate distribution.

EXPERIMENTS ON MILK.

Experiment 1.

To examine a sample of milk.

mine a sample of fresh cow's milk and notice that it is an , creamy white liquid. It has a slightly sweet taste, a faint t odour and a greasy feel.

pieces of red and blue litmus paper into the milk and then hem under the tap. What changes have taken place ? Is cid or alkaline ?

Experiment 2.

To examine a drop of milk under a microscope.

e a small quantity of milk with about an equal volume of nd place one drop of this mixture on a microscope slide with rod. Cover the drop carefully with a cover slip so that no bles are formed. Examine the drop under the low and high of the microscope.

The tiny circles seen are minute drops or globules of fat. these tiny drops of fat which give milk its colour. When f broken up into tiny drops like this it is called an emulsion and is r more easily digested in this form.

Experiment 3.

To find what happens when milk is allowed to stand.

Allow some milk to stand for a few hours in a tall jar. W do you notice ? The layer at the top of the milk is cream an formed by the drops of fat seen under the microscope, rising to surface and adhering in bigger drops.

Take out some of this cream and rub it on a piece of filter pa Notice that the paper becomes semi-transparent. This shows cream is a fat.

Experiment 4.

To find out why a skin forms on milk when it is heated.

Half fill an evaporating basin with milk and warm it gently wire gauze over a Bunsen burner until a skin is formed. This is formed in part by the evaporation of water from the milk in part by the setting or coagulation of the protein, lactalbu which the milk contains. White of egg is a similar substance sets in just the same way when an egg is boiled.

Now heat a second quantity of milk but cover the basin wit piece of stiff cardboard. A skin is formed this time but ther very little evaporation from the surface of the milk. The ca in milk is present as calcium caseinogenate which on heatin hydrolysed and along with the fat h to form a skin. It is the formatio this skin and the collection of st underneath it which causes milk boil over so easily. Is it better boil milk in a pan with the lid on off?

FIG. 38. Cream-Testing Jar.

Experiment 5.

To test the quality of a sample of m

(a) *The cream tube test.*

Pour 100 ccs. of milk into a mea ing cylinder and leave it to st undisturbed until all the cream separated out. Read the volum cream. A good sample of milk sh contain at least one tenth of its vol of cream.

(b) *The specific gravity test.*

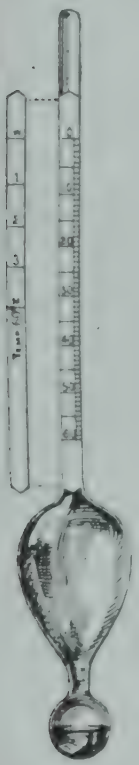
Weigh a specific gravity bo empty. Then fill it with

eigh again. The difference in weight is the weight of the Now fill the bottle with water and weigh it. By subtracting ight of the empty bottle from the last weighing we get the of water. We now know the weights of equal volumes of and milk, and to find the specific gravity of milk or the number es milk is heavier than the same volume of water we divide ight of milk by the weight of water.

$$\text{ific gravity of milk} = \frac{\text{Weight of milk}}{\text{Weight of equal volume of water.}}$$

specific gravity of good milk is between 1.028 and 1.034.

If you have not got any specific gravity bottles you can use a small flask with a mark on the neck.



39. Lactometer.

(c) *The Lactometer.*

This instrument is a special form of hydrometer which will very quickly and conveniently measure the specific gravity of milk.

Notice that it consists of a glass stem containing a scale, a float and a sinker. When placed in any liquid it floats in an upright position. The heavier the liquid in which the lactometer is placed the higher it floats, and the lighter the liquid the lower the lactometer sinks.

Place the lactometer in water in a tall jar. Notice that the stem sinks to the mark O on one side of the scale and W on the other. Now place the lactometer in milk. The lactometer now floats much higher and if the milk is good milk the lactometer will float at the letter M on the scale and some figure between 28 and 34.

Add water to the milk and test again with the lactometer. What do you notice ? Leave the milk to stand for a few hours until cream begins to form and then remove some of the cream. Shake up the remaining milk and test again with the lactometer. Is there any difference ?

The lactometer is used by Foodstuffs Inspectors when testing milk. Is it a really reliable test ?

Experiment 6.

To separate milk into curds and whey.

(a) *By bacteria.*

eave some milk to stand for a few days and examine it at the of this time. There is a thick clot at the top of the milk (curds)

and a watery portion underneath (whey). This change has b brought about by bacteria which are always present in milk and into it from the dust of the air. These bacteria feed upon the su in milk and change it into an acid (lactic acid), which curdles milk.

(b) *By acids.*

To two test-tubes half-full of milk add a few drops of vinegar the first and a few drops of lemon juice to the second. A c quickly separates out owing to the acids in the vinegar and lem juice (acetic and citric acids respectively)

(c) *By rennet.*

Obtain some rennet tablets or extract from the chemist a a small quantity of some milk warmed to blood heat (98° F. or 37° C and leave to stand. The milk will set solid on cooling owing to t action of the rennet. Break it up with a glass rod and note again the curds and the whey.

Experiment 7.

To show that curd is a protein.

Dry some of the curd between blotting paper or filter pape Notice the greasy nature of the paper, indicating that cream is al present. Place a small piece of the curd on a piece of broken po and heat over a Bunsen flame. Notice the fumes which smell lik burnt feathers or hair. All proteins such as gluten, white of egg lean meat and curd give this smell on heating.

Now place another piece of curd in a test-tube and add lime o caustic soda and warm gently. Smell the fumes given off. Tes them with moist red litmus paper. If the fumes smell like ammoni and turn the moist red litmus paper blue this is a further proof tha curd is a protein.

As a third test, cover a small piece of curd in a test-tube wit concentrated nitric acid. (Be careful when using this substance. Heat the mixture to boiling and notice that it turns yellow. Coo under the tap and carefully add ammonia. The colour should now be orange. Only proteins will give this test. The protein in curd is known as casein.

Experiment 8.

To examine the properties of whey.

(a) Taste the whey. Does it taste sweet or sour ?

(b) Pour some whey into a test-tube and add to it a few drops of Fehling's Solution No. 1, and then Fehling's Solution No. 2. Place it in a beaker or aluminium cup with water and heat to boiling.

The mixture is blue to begin with, but rapidly changes until it is reddish brown. Repeat the same experiment using glucose (grape sugar), and notice that you get the same changes in colour.

This experiment proves that whey, and therefore milk, contains a sugar. This sugar is known as milk sugar or lactose.

Experiment 9.

To separate the milk sugar from whey.

porate some of the whey almost to dryness in an evaporating placed on a water bath or aluminium cup containing water. leave the evaporated whey to cool. Crystals of milk sugar tose will slowly crystallise out. Taste them and examine appearance under the microscope.

Experiment 10.

To show that whey contains mineral substances.

at the remainder of the whey from the previous experiment porcelain dish over a Bunsen flame. Notice that it first of all nes dry and then turns black and gives off the smell of burnt . Finally you are left with a small amount of white ash, which not burn away no matter how long you heat it. This ash ins the mineral substances from milk which are so valuable bies and young children in building up their bones and teeth.

Experiment 11.

To determine the amounts of water and solids in milk.

(N.B.—This experiment takes a long time and other experiments should be carried out along with it.)

eigh an evaporating basin empty. Add about 20 ccs. of milk weigh again. Subtract to obtain the weight of the milk. Now the milk in a steam oven or an air oven or on a water bath until he water has been evaporated away. Allow the basin to cool then weigh. By subtracting the weight of the empty basin weight of the solids is found. The percentage of solids is worked as follows :—

$$\text{Percentage of solids} = \frac{\text{Weight of solids}}{\text{Weight of milk}} \times \frac{100}{1}$$

our result should be about 13 per cent. The remaining 87 per . is water. In spite of this large amount of water milk is reled as Nature's most perfect food particularly for babies and ng children who are still growing.

Experiment 12.

To illustrate methods of preserving milk.

or this experiment you require six test-tubes, a test-tube rack, a gummed labels and some sterilised cotton wool. The testes should be perfectly clean.

nto the first test-tube pour fresh milk until the tube is two-thirds Label it A, and place it in the rack. Pour an equal quantity ilk into the second test-tube. Plug the top with sterilised cotton l and label it B. Place in the rack next to A.

Now scald or pasteurise two test-tubes two-thirds full of by heating in a beaker of water to 65° C. for 30 minutes. L them C and D. Plug D, and place them in the rack.

Finally place the last two test-tubes with the same volum milk in boiling water for 30 minutes. Label them E and F. F and place these in the rack with the others.

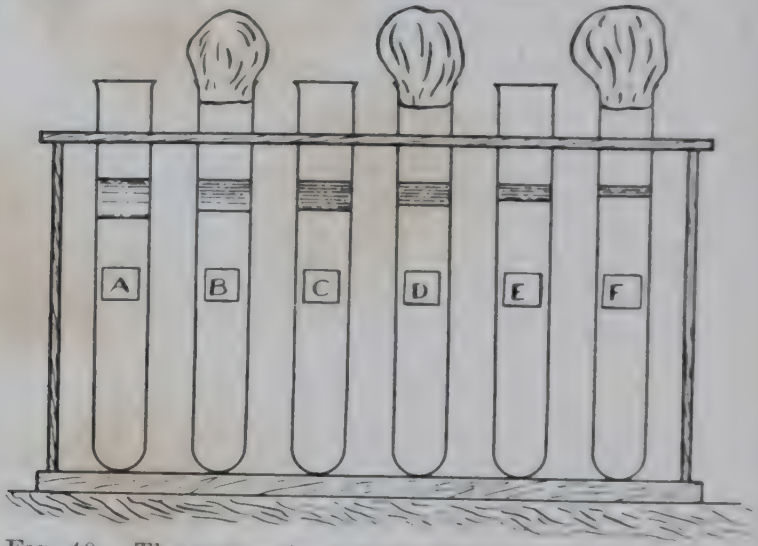


FIG. 40. The comparison of methods of milk preservation.

Examine the test-tubes from day to day and notice the order which they turn sour. You should find that they turn sour in t order in which you placed them in the rack.

A. corresponds with milk in an open jug. It contains bacte and others can get into it from the air.

B. corresponds with milk covered in a jug or in a sealed bott It contains some bacteria but others are prevented fro getting in.

C. The scalding or pasteurisation destroys most of the bacteri but fresh ones get in from the air.

D. Most of the bacteria are destroyed by pasteurisation a none can get in from the air.

E. All bacteria in the milk are destroyed but fresh ones ent from the air.

F. All bacteria in the milk are destroyed and others prevente from entering.

Experiment 13.

To compare pasteurised and sterilised milk.

Pasteurise and sterilise two test-tubes of milk as in the previou experiment. Cool and taste the two samples. Do you notice an difference ?

heating to 65° C. as in pasteurisation most of the bacteria k are destroyed without coagulating the lactalbumin and g the taste. By heating to 100° C. all the bacteria are de- l but the lactalbumin is coagulated and the taste altered.

Experiment 14.

compare condensed and dried milk powder with fresh milk.

ain some condensed milk and milk powder and make them quid milk by the addition of water according to the instruc- on the tins.

Compare the tastes with that of fresh milk.

Place equal volumes of the two together with an equal volume of fresh milk in three separate measuring cylinders and leave to stand. Compare the amounts of cream formed in each case.

Warm equal quantities of each to blood heat and add rennet. Compare the clots obtained in each case.

What advantages have condensed milk and milk powder over fresh milk? In what ways is fresh milk better.

Experiment 15

To distinguish between fresh, pasteurised and boiled milk.

sh milk contains enzymes capable of transferring oxygen from oxide, e.g., hydrogen peroxide, to an oxidisable substance. ' peroxydase ' enzymes are destroyed when milk is heated out 80° C.

ce 5 ccs. of fresh, pasteurised and boiled milk in three separate ubes. Add two drops of 1 per cent. solution of p-phenylene ne and 1 drop of dilute hydrogen peroxide solution (10 volume on diluted 1 in 50) to each sample. Note in which cases a purple colouration is produced and the times taken for its rance.

Experiment 16.

To examine the treatment of milk in infant feeding.

ce 50 ccs. of the following liquids in boiling tubes, add 20 of extract of rennet to each and place together in a water at 40° C.

i.) Half milk and half water.
ii.) Half milk and half barley water.
iii.) Condensed milk made up according to directions on the tin.
iv.) Any brand of baby food made up according to directions.

npare the clots produced and draw conclusions as to the ibility of the various products and their suitability for infants.

CHAPTER XVI.

MILK PRODUCTS.

Milk is remarkable among natural foods because of t great variety of processed foods prepared from it, most them having the great advantage over the original su stance in their properties of preservation. Chief amo the different forms of milk products are the following

Cream.
(Ice Cream.)
Separated and Skimmed Milks.
Butter Milk.
Condensed Milk—Sweetened and Unsweetene
Milk Powders.
Butter.
(Margarine.)
Cheese.
Fermented Milks.

Cream. When milk is allowed to stand the globules o fat, being lighter than the rest of the mil gradually rise to the surface and form a distinct layer c cream, the volume of which is about one-tenth that o the milk. This cream can be separated by skimmin it off, or by the use of a separator, which is a speciall constructed centrifugal machine. The former metho is nothing like so efficient as the latter. Skimmed mil contains about 1 per cent. of fat and the skimmed crea about 70 per cent. water, 20 per cent. fat and 10 per cent other solids. Machine separated cream contains betwee 50 and 60 per cent. of water, 30 to 35 per cent. fat, an 10 to 15 per cent. solids other than fat. The amount o fat left in separated milk is almost negligible. Separated cream also contains less bacteria than skimmed crea for this is not taken off the milk until it has stood fo some considerable time up to 24 hours. This gives time for the multiplication of micro-organisms: skimmed crea will not keep fresh anything like so long as separated

. In the past many preservatives have been used eam but their use is now illegal. It was also a ion practice to add thickening materials to cream, as starch, mucilage, gelatine, or sucrosate of lime, he use of thickening agents of any type is now pro- d under the Public Health (Preservatives, etc., in) Regulations.

spite of these regulations as to the addition of pre- tives and thickening agents to cream there is no standard in England for the fat content of cream, n is the best criterion of quality. The fat content s enormously according to the method and thorough- of preparation, and may be as low as 15 per cent. high as 60 per cent. Ordinary home skimmed cream ains between 15 to 20 per cent. fat. Commercial rated cream is sold in two grades—'single' cream aining about 25 per cent. fat, and 'double' cream aining 50 to 55 per cent. fat. Like other natural the fat of cream consists of a mixture of glycerides; e are chiefly palmitin, olein and butyrin. The nce of butyrin gives cream its superior flavour and tableness as compared with other fats. Devonshire m, Cornish cream, or clotted cream is made from which has been allowed to cream for 12 hours is then scalded for 15 minutes at 187° F., ng which period water evaporates from the cream and the caseinogen and albumin coagulate. The is allowed to cool for 24 hours, and then skimmed. nty-three pans of milk yield as a rule one pan of clotted m.

Composition of Clotted Cream.

	per cent.
Fat	63·0
Water	29·5
Protein	4·05
Lactose	2·80
Ash	0·67

eam can be whipped or beaten to form froth which is ost as stiff as that of white of egg. Fresh cream does

not whip so easily as older cream of greater acidity, a beyond a certain limit butter is produced instead whipped cream. The whipping qualities of cream thought to depend upon the amount of calcium pres in it, but a complete explanation has still to be giv Cream containing some thickening agent whips bet than pure cream.

Reconstituted Cream. This may be made by agitation good unsalted butter in separat milk. The globules of the butter fat are broken up a preserved by the adsorption at the surface of protei from the milk. Such re-made cream is scarcely to distinguished from ordinary cream.

Ice Cream. The cheaper forms of ice cream are not mad from cream, but from milk, sugar and cor flour, together with some flavouring and colourin materials, heated together and afterwards frozen. Whe stale milk is used the bacterial content is often very hig indeed. The chief bacteria are the true lactic bacteri but at low temperatures the putrefactive and alkal forming bacteria grow in excess of this group and foo poisoning may result.

The best ice cream is made from the cream of mil partially ripened at 15-20° C., and then frozen. Thi contains practically no bacteria except the lactic aci group and hence if kept frozen is wholesome for a muc longer period than the other types of ice cream.

Separated and Skimmed Milk. These are milks from which the fat has been removed either by a separator or by hand skimming. A a food for infants such forms of milk are to be condemned on account of their deficiency in fat, but as ingredient in articles of food which contain fats their use is to b commended on account of the protein, sugar and minera constituents. Such milks are frequently employed in making bread, cakes, biscuits and ices.

cal analyses of Separated milk are :—

ater	...	...	...	90·3 –90·7	per cent.
t	...	...	...	0·05 – 0·2	„ „
otein	...	...	...	3·6 – 4·0	„ „
ctose and Lactic Acid				4·7 – 5·0	„ „
sh	...	...	...	0·75 – 0·8	„ „

milk. Buttermilk is the waste product of butter manufacture. It contains the constituents original milk except fat, and is distinctly acid. cidity is due to the activity of lactic acid bacteria ning lactic acid from the milk sugar.

$$C_{12}H_{22}O_{11} + H_2O = 4\ C_2H_5O.COOH$$

termilk is used to some extent in baking scones uns ; its acid liberates carbon dioxide from the onate of soda used as an aerating agent.

nsed Milk. Condensed milk is made by the removal of a large proportion of water either full cream or separated milk. The milk is rated to about one third of its original volume in m pans in which the temperature does not rise 66° C., at which temperature the lactalbumin be coagulated and the condensed milk have a d flavour. The condensed milk may be left unened or may have sugar added to it. The addition gar improves the flavour and checks bacterial h. Whether full cream, separated, sweetened or eetened, the condensed milk is hermetically sealed in sed tins and must have a label attached giving a description of the contents. Unsweetened cond milk is frequently prepared by heating the milk emperature between 100° and 110° C. and is subto further sterilisation after pouring into the tins. s necessary to prevent bacterial action, as in this case ntiseptic action of the sugar in sweetened condensed is lacking.

Composition of typical Condensed Whole Milks.

Ingredients.	Unsweetened per cent.	Sweetene per cent
Water	... 62·8	25·3
Fat	... 10·8	10·8
Protein	... 10·02	10·02
Lactose ...	... 14·0	14·1
Added Sugar ...	... —	37·5
Ash	... 2·28	2·28

Condensed milks, as a result of their heat treatm and storage in sealed tins, contain less bacteria t fresh milk and are less likely to spread infectious disea Their use for infants is open, however, to certain jections. Condensed skimmed milk is deficient in Sweetened condensed milk contains excess cane su which is liable to affect digestion. The dilution of s milk with water to give a more correct sugar cont gives a product which is still more deficient in fat. C densed milks are most useful as emergency supplies.

Milk Powders, Dried and Desiccated Milks. These are produced by moval of the water from m at such a temperature th the constituents are as little altered as possible. Th are produced from whole milk, separated milk or butt milk by a variety of methods. One method consists drying the milk by allowing it to fall on to steam-heat revolving cylinders on which it dries rapidly in thin film The process most commonly used at the present time the "spray process" in which a spray of milk is project under pressure into a chamber into which is blown blast of hot filtered air at a temperature which shou not exceed 148° F. (64·5° C.). The fine droplets of m come into contact with the hot stream of dry air, quick lose their water by evaporation, and fall to the botto of the chamber as a fine powder. The proteins of t milk—caseinogen and albumin—are not coagulated, a the resultant product is easily soluble in water giving reconstituted milk that is only very slightly flavoured.

milk powders will keep indefinitely, provided re kept dry, and are particularly suitable for bread nfectionery purposes. They are also used as the f baby foods, and are made to correspond more to human milk in composition by the addition of ugar.

Composition of a Typical Milk Powder.

	per cent.
Water	2·50
Fat	28·21
Protein	26·61
Lactose	36·81
Ash	5·87

umber of buttermilk powders are on the market as bread improvers. Their use increases the acidity dough, and so produces a greater softening of the which is particularly advantageous in the case of flours.

Butter is prepared by churning separated cream after it has 'ripened.' The cream is d to ripen to improve the flavour and to break the emulsion by the formation of lactic acid. The ng is a bacterial action due chiefly to lactic acid ia, and is brought about by keeping the cream in a place and adding a sour milk culture as a 'starter,' cially prepared lactic acid bacteria. The churning tes the fat globules from the rest of the cream, caseinogen, lactalbumin, lactose and mineral r. The fat is collected, pressed into moulds with n butter pats so as not to spoil the 'grain,' and orked in as a flavouring agent and preservative. e colouring matter, such as annatto, is occasionally d in to give the butter a more pleasing appearance.

commercial value of butter depends largely upon vour, which in its turn depends on the micro-organ- present and their regulation. The temperature nufacture, 10°-20° C., is more favourable to the h of the lactic bacteria, Streptococcus lacticus, etc.

than that of the coliform bacteria, which produce uns
factory flavours when present in appreciable proporti
Spontaneous ripening of cream favourable to the p
duction of good butter shows the maximum numbe
bacteria after 24 hours at 20° C., The cream t
thickens and it is time to stop ripening by churning a
washing out the remaining lactose or, if this is impra
able, by cooling the cream. Any further ripen
beyond this point encourages the growth of undesira
bacteria.

The old practice of controlling ripening by keepi
over samples of sour milk which had given good but
one day to the next, and so continuing until some u
wanted organisms accidentally developed, is now
placed in industrial butter manufacture by the use
pure cultures of the lactic organisms. These are se
out as liquid culture, inoculated milk or a dried powde
The culture is added first to some pasteurised skimm
milk, and incubated until curdling commences and
curd finally forms with an acidity of 0·5 to 0·7 per cen
of lactic acid. This ' starter ' is added to the cream no
usually first pasteurised. The resulting butter is a stan
ard product, with a mild flavour, which has gradual
established itself in the public favour against the unce
tainly flavoured farm-house product.

The composition of butter is liable to considerab
variation for a number of reasons, but a general averag
composition is as follows :—

Composition of Butter.

	per cent.
Fat	85
Curd	1
Salt	1
Water	13

In England the percentage of water is limited by law
to 16 per cent.

The superiority of butter over all other fats is largely
due to the presence in it, as in milk and cream, of fat

melting points, and vitamins A and D. The
e fats, chief of which is butyrin, give butter its
nt taste and smell. The distinctive flavour of
is imparted to any baked goods in which it is used
erence to any other form of fat. Since these points
eriority are due to the volatile fats in butter it is
s that it should not be melted until it is to be
or the volatile ingredients will be lost by evaporation
will lose much of its value. Unfortunately these
e fats are easily turned rancid by bacterial action ;
nell of rancid butter is largely due to butyric acid
d by decomposition of butyrin. Butter should
s be well covered and stored in a cool place.

rine.

rgarine was discovered during the Franco-German
of 1870. The French Government had offered a
ntial prize for the production of a butter substitute
ke up the shortage of butter supplies. The prize
won by Mége-Mouries who had observed that cows
without food for a period and given water only to
continued to give milk. From this he deduced that
nilk must be formed from the fat of the animal
cting on this assumption he took the caul fat of the
ck and pressed it. He first obtained a fat which
ne known as "Premier Jus" and by still further
ing he obtained a liquid oil known familiarly as
o." By churning this with milk he succeeded in
ning an artificial butter which became the basis
e supplies of margarine in those days.

ufficient animal fats led to use in later years of edible
rom a variety of nuts and other seeds ; the range
ese has increased year by year. These vegetable
vere at first used in the form of soft liquid oils but
by the process of hydrogenation they can be hardened
ke exactly the same place as the harder animal fats.
table margarines are now the most important class
argarines.

rgarines may be defined as very stable emulsions
and water prepared by emulsification of animal and

vegetable oils with milk. The two classes of margar
are **oleo-margarines** in which the animal fats and
predominate over the vegetable oils and **vegeta
margarines** in which the quantities of vegetable
predominate.

Margarine when properly prepared under clean conditions
highly nutritious article of food. Its nutritive value has
improved by the addition of useful amounts of vitamins A an
An important difference between butter and margarine is the abs
of butyrin from margarine. This volatile fat gives butter its sup
taste and smell. Better quality margarines contain added bu
fat but the amount is limited by law to 10 per cent.

Margarine has two advantages over butter apart from price.
keeps better, and margarines of different types can be prepa
suitable for different purposes. Thus, if we compare the consti
ents of the following three types of margarines we shall see that
ingredients make them suitable for their particular purposes.
butter were used it would be used indiscriminately for all th
purposes.

Composition of Grocery Margarine.

Lard	42	per cent.
Oleo Oil ...	40	,, ,,
Premier Jus ...	6	,, ,,
Pea-nut oil ...	12	,, ,,

450–550 I.U's. vitamin A and 90 I.U's vitamin D

Here are high quality animal fats with very little vegetable
The prime consideration is food value.

Composition of Cake Margarine.

Coconut Oil ...	50	per cent.
Premier Jus ...	20	,, ,,
Oleo Oil ...	20	,, ,,
Pea-nut oil ...	10	,, ,,

The vegetable constituents are included to give the mixture t
same creaming qualities as butter.

Composition of Pastry Margarine.

Oleo-stearine ...	30	per cent.
Premier Jus ...	25	,, ,,
Palm kernel oil...	35	,, ,,
Pea-nut oil ...	10	,, ,,

Here hard tough waxy fats are used to give the requir
consistency and 'shortening' properties.

se is made from milk by curdling the caseinogen, by the addition of so-called pure cultures of lactic cteria (acid-curd) or, far more generally, by the n of the enzyme rennin contained in rennet, the of the digestive stomach of the calf. Rennet are of two kinds, hard and soft; the difference argely due to the almost complete removal of whey first, while in the soft cheese a considerable amount in.

he making of Cheddar cheese the best milk is that which acidity of about 0.2 per cent. lactic acid, brought about, if , by the addition of pure cultures of lactic acid bacteria. is added at this point and a rubber like curd is formed. anding for some time the curd is cut into small cubes and the n off. The curd consists of casein and milk fat, while the mineral salts, lactose, and lactic acid are largely in the whey. d increases in the cubes, the nature of the curd changes, and es are salted and melted to form a homogeneous mass, s kept in the salting vat for several days, being turned and every day. The next process is that of ripening, in which d changes take place. This occurs in underground well ooms at 15° to 25° C. The flavouring substances are devel- nd the digestibility improved, the 'soluble nitrogen' being ed to a large extent. The development of flavour is entirely bacteria (almost entirely Streptococcus lacticus) over which aker has very little control in this direction. The pepsin in the rennet, in the presence of acid, acts on the casein, y converting it into the soluble albumoses and peptones. It ible that the enzyme lactase may also play a part in the g. As the ripening process goes on the cheeses are turned nd rubbed well with oil. The bacteria which effect the ripen- y find their way into the cheese naturally through the milk or e atmosphere of the dairy. In large modern cheese factories e introduced into the cheese as pure cultures. The ripening cheese is the most important part of its preparation and re- skill and care if the cheese is not to be spoilt.

The food value of cheese is particularly high; . indeed there is no foodstuff ordinarily available which approaches it in respect both of concentration f variety of food principles. An average whole milk consists in roughly equal parts of water, of proteins f fat; there are also appreciable quantities of milk and minerals, among which calcium is most ant. The proteins consist mainly of casein and its

soluble derivatives—albumoses, peptones and amino-a
Casein itself is a protein of the first class, and yield
the amino-acids that are required for the synthesis of
proteins of the different tissues. As a source of org
phosphorus it is particularly valuable in the building
of the cell nuclei of nervous and glandular tiss
Casein is readily and thoroughly digested, at least wh
has passed the stomach and been dissolved by the alka
of the bile. The fat, being butter fat and having a
melting point, is easily dealt with by the stomach, if
in too large a quantity, and unless it has happened t
in the course of ripening an excessive amount of
butyric acid has been formed. As a ready and ch
source of energy a hard full milk cheese is much supe
to raw beef, yielding some 2,000 Calories per pound
against 1,100 Calories from fore-quarter, and 700 Calo
from lean beef. In the matter of vitamins, cheese c
tains those found in the milk from which it is produc
chiefly vitamin A and Riboflavin.

Types of Cheese. Cheese may be made from whole m
(Cheshire and Cheddar), skimmed or separat
milk (Edam and Gouda), or milk to wh
cream has been added (Stilton and Gorgonzola).

The differences between the many varieties of chee
depend upon the method of preparation and m
especially the method of ripening.

Varieties of Cheeses. These differ according to the original sou
of the milk—whether cow's milk or goat's
but largely according to the details of t
several steps of the process by which t
cheese is made, and such modifications as materia
affect the activity of the chief organism concerne
Streptococcus lacticus, and of the subsidiary bacte
and moulds.

Hard Cheese.

English : hard pressed : Cheddar, Cheshire, Glo
cester, Lancashire a
Leicestershire.

blue veined : Stilton, Wensleydale a
Dorset.

inion : Canadian, New Zealand and Australian.

ign : Dutch Cheddar, Edam and Gouda, Gruyère, Gorgonzola, Roquefort, and Parmesan.

Soft Cheese.

ish : York cream cheese, Lactic acid, Wilts, and cream cheese.

ign : Camembert, Brie and Bondon.

ND PRESSED CHEESES.

es of the Cheddar Type are made more or less according to eral scheme already described. Coloured cheeses of this made by the addition of annatto. Canadian cheddars are ped in melted paraffin wax before shipping, the purpose conserve the natural moisture and to ward off the attacks ts.

all Cheddar cheese weighs about 12 lbs., and corresponds 12 gallons of milk. A full size Cheddar weighs about and is 15 inches high and across.

ire Cheese is either white as when made for the Manchester or artificially coloured, and weighs either 65 or 90 lbs. It and flaky in texture, and mild and mellow in flavour. It is ctured in three varieties :—early ripening,—being ready for rket in a month, medium ripening, and slow ripening. ture is due to the methods of treating and pressing the curd, particular flavour to the type of bacteria associated with ries in which the cheese is made. Ripening is hastened or l by slight modifications in the process of manufacture.

and Double Gloucester (the former weighing 16 lbs., and the 0 lbs.) are of the mild Cheshire in type.

p is a Cheddar type cheese made in Scotland and weighs 6 lbs.

shire cheese is largely restricted in its manufacture and ption to that county. It has excellent toasting properties. en three months old is soft, mellow and crumbly, and ad- suited for spreading on bread like butter. Its acidity s slowly and its characteristic friability is due to the mixing urds at different stages of acidity. During maturation it considerably. The cheese is usually made in two shapes : and flat, 14 inches across and weighing 44 to 50 lbs., and the ke a small Stilton, 8 inches across and 6-6½ inches high, g 10-12 lbs.

and Leicester cheese of the Cheddar type weigh about s.

Stilton cheese is made by much the same process as Cheddar. It is in the first place an ordinary lactic acid cheese, but the mould *Penicillium roqueforti* gains entrance through cracks in rind as this dries, and develops slowly in the interior as blue surfaces and streaks. The usual weight of a cheese is 15 lbs. it corresponds to rather more than 16 gallons of new milk some brands of Stilton cheese extra cream is added to the milk.

Wensleydale Cheese is a blue-veined cheese which closely resembles Stilton, but has a much more limited market, chiefly Yorkshire Lancashire, and suffers in reputation in being marketed too before being fully ripened. When kept, it is invaded by the green mould which forms delicate blue veins well distributed throughout the curd. A typical cheese of the Stilton shape, weighs from 10 to 12 lbs. ; its flavour is rich, sweet and creamy when matured.

Dorset Cheese or ' Blue Vinny ' was formerly much manufactured in Marshwood Vale, and being made from skimmed milk, its manufacture was accompanied by that of butter. Dorset with neighbouring counties has now largely gone over to the liquid milk trade, and local cheese of good quality is not easily come by.

Canadian Cheddar weighs about 80 lbs. ; it has a cloth closely hering to its sides. America and New Zealand Cheddar are similar to Canadian Cheddar in most respects of size, colour and consistency.

Both *Edam* and *Gouda* cheeses are Dutch in origin. The former is round and red skimmed and is graded 40, 30 and 20 per cent. fat, and weighs about 4lbs. Goudas are flat and red or yellow skinned and graded 45, 40, 30 and 20 per cent. fat. They are salted in brine for several days and ripened for a month before being sent out.

Gruyère or *Emmenthaler* cheese, made in Switzerland, has a sweetish flavour and is distinguished by ' holes ' or eyes in the interior, produced in the generation of gas in the making. In this case fresh cow's milk is fermented by rennet and kept at 30° C. for a day or two. The curd is cut up and salted for some time, during which the lactose disappears very rapidly under the action of Bacterium bulgaricum and a gas-forming organism, the activity of which is favoured by the lack of acid due to the use of fresh milk; for much lactose is lost in the whey.

Gorgonzola from Lombardy, Italy, is made from fresh whole cow's milk and of a combination of cold and warm curd. In making, the cheese is infected naturally by the spores of Penicillium roqueforti which abound in the caves and cellars in which it is stored. Oidium lacticus develops on the surface. Gorgonzolas are from 12 to 18 lbs. in weight, packed in separate baskets and should be coated only with a natural rind.

Roquefort cheese is made from sheep's milk, the first stages in the process being much as already described for hard cheeses. The characteristic blue is due to the abundant growth of Penicillium

ti, which has been introduced by a special culture. The sprinkled before melting with mouldy bread crumbs, and ripening is pierced with needles to allow air to get to the the interior. Strict regulation of the temperature and of the storage of the ripening cheese is essential to the on of this type of cheese. Danish Roquefort is made in a ashion, and is covered with tin foil when ready for marketing.

san, a cooking cheese from Italy, has a very hard texture, colour and a very tough and almost black rind. It is various dishes, as of macaroni.

us pasteurised cheeses are now sold made up in five pound or in small wedges, wrapped in tin foil. The cheese is rindless nade from ordinary Cheddar cheese and others, freed from , ground up and pasteurised.

HEESES.

n cheeses are of many kinds, their consistency, flavour, pending on the proportion of cream used, the treatment of k and the cream at the various stages of manufacture, and ning of the cheese. In some kinds no rennet is used; the poured into a muslin bag which may be kept in a perforated hung up in the warm air, and allowed to undergo bacterial on its own account. In other kinds cream is added in knead- curd formed by rennet to give a soft and creamy consistency.

l Lactic Cheese is a cream cheese in the manufacture of which acteria, including B. bulgaricum, have been used.

mbert cheese is made by the action of rennet on ripened ilk. The whey is allowed simply to drain off, so that the ontent is very high and the bacterial growth rapid. The levelops a strong surface growth at first of Oidium lacticus, er of the mouki Penicillium camemberti. These produce s which gradually digest the cheese from the outside inwards, of demarcation being quite sharp. The cheese is ready for le when the change has taken place throughout. Acidity ed and consequently the putrefying bacteria make entrance as soon as ripening is completed. Very strict conditions of ature and humidity are required during ripening to preserve per bacterial balance. Camembert is sold as a small round about 1½ inches thick and 5 inches across, in white chip with a stamped label on top.

urger cheese ripens both from the inside, due to the enzymes et and lactic bacteria, and from the outside due to moulds rind. Two bacteria live in symbiosis on the exterior: the dises the lactic acid to acetic and carbonic acid, and lives on mo-acids produced by the action of the other on the curd s and liberates free ammonia gas which neutralises the acid

formed as it diffuses inwards and so permits other putre bacteria to develop. The powerful flavour characteristic cheese is due to products of putrefaction, such as indole a phuretted hydrogen.

COMPOSITION OF CHEESES.

(After R. H. A. PLIMMER)

	Percentages.				
Class.	*Water*	*Ash*	*Protein*	*Fat*	*Calo per*
A. **Soft**					
Little Wilts.	40·4	1·5	22·0	32·3	1807
B. **Hard.** (Full).					
Cheddar ...	33·7	2·6	25·2	33·4	1939
Cheshire ...	34·9	2·5	22·7	33·8	1910
Gloucester ...	30·9	2·7	25·6	36·6	2068
Wensleydale	26·3	3·1	29·2	35·1	2083
C. **Hard.** (Skim)					
Blue Dorset...	32·7	2 8	41·9	14·4	1472
D. **Hard.** (with added cream)					
Stilton ...	24·6	1·4	26·3	42·8	2341

Fermented Milks.

The most primitive method of preserving milk is fermentation, a practice still followed by nomads peasants in many parts of the world, according to det peculiar to the district, or to the source of milk, whet from cow, sheep, goat, camel, mare, reindeer, etc. Q recently the preparation of sour milk had a vogue in t country.

main types of milk beverage may be distinguished, rvescent and the non-effervescent.

VESCENT NTED — Examples are Kefir as made in South Russia and the Balkans, and Koumiss as made from mare's milk in Russia.

is made in skins by the addition of 'kefir grains" milk of cows, goats or sheep, so that this is fer- to a drink containing 1 per cent. alcohol and cent. lactic acid. The grains are yellow nodules sed of bacterial filaments entangling yeast cells: rmer consist of different organisms, decomposing with the evolution of gas and not curdling milk, ne latter of a special yeast fermenting malt and ugars but not milk sugar. Koumiss is fermented nare's milk by a starter carried over from the last consisting of a yeast of the lactose fermenting nd an acetic acid bacterium. A simultaneous lic and acid fermentation results in about 1·0 per of alcohol and 0·75 per cent. of acid. Similar ted milks are prepared in Egypt and Norway by yeasts and bacteria in symbiosis.

FFERVESCENT — Examples are Yogurt (Turkish), Kindo Mleko (Balkans), Matzoon (Armenia), etc. These are all thick l milks containing lactic acid and a very little l. They are made from the milk common in the s regions, the result mainly of Bacterium bulgar- The coagulated milk does not separate into curd hey, even on standing and may become decidedly taste. Other bacteria as well as yeasts are present odify the flavour. The high acidity inhibits the of pathogenic and putrefactive bacteria, so that nilk beverages may be safely kept for a long time. ay be recalled that Professor Metchnikoff attri- the well-known longevity of the Balkan peasantry r practice of drinking large quantities of fermented and suggested that the Bacterium bulgaricum shed itself in the intestines and produced there

sufficient lactic acid to check the putrefactive and har bacteria generally to which he ascribed much of th crepitude of old age. His suggestion started a v for the preparation and drinking of fermented m which however after a year or two died down comple The bacillus is ordinarily to be found in the intes and acts on the lactose of any milk that may be inge so that there is really no need to drink quantiti specially soured milk Apart, however, from the aggerated claims made for it, soured milk might be drunk more frequently, for it is a pleasant and refr ing drink, and more digestible than ordinary fresh m

EXPERIMENTS ON MILK PRODUCTS.

EXPERIMENTS WITH CREAM.

Experiment 1.

To test cream for artificial thickening agents.

The addition of any type of artificial thickening agent is illegal, but gelatine, gelatinised starch and cane sugar have used for this purpose in the past.

(a) Gelatine.

Make a mixture of about 5 gms. of the cream and 10 ccs. of wa Add 1cc. of acid mercuric nitrate solution. Shake well. Filte remove the precipitated proteins and fat. To the filtrate ad saturated picric acid solution. The precipitation of a ye precipitate indicates the presence of gelatine.

(b) Starch.

Prepare a mixture of the cream and water as in the prev experiment. Add to it a few drops of a solution of iodine in po sium iodide solution. In the presence of starch a blue colour is produced.

(c) Cane sugar, or sucrosate of lime.

To a mixture of 5 gms. of the cream in 10 ccs. of water in a t tube, add about 0·5 gm. of powdered ammonium molybdate 5 ccs. of dilute hydrochloric acid. Place the test tube in a w bath and heat to between 80 and 90° C. In the presence of sugar a blue colour is produced. Milk and cream free from ad cane sugar will give a similar colour only on boiling.

Experiment 2.

To test cream for added preservatives.

se of preservatives of any type in cream is now illegal acid or borax and formaldehyde have been used in the past rvatives both for milk and cream. The tests for these sub- n either milk or cream are the same.

c acid or Borax.

about 1 cc. of the milk or cream in an evaporating basin. drop of concentrated hydrochloric acid and stir together lass rod. Add a few drops of saturated alcoholic turmeric . Evaporate to dryness on a water bath. In the presence acid or borax a pink colour is developed even with minute es of the preservatives. If the mixture is heated too strongly our turns brown.

maldehyde—Hehner's test.

t half fill a test tube with milk or cream and pour carefully e side of the tube about half the bulk of commercial con- d sulphuric acid. The sulphuric acid will sink to the bottom parate layer and in the presence of formaldehyde a violet produced at the junction of the two layers. It is important test to use commercial sulphuric acid since the test depends e presence of traces of iron.

interesting in carrying out these tests to use the sample of cream as supplied and then to a second portion to add a ric acid and to a third portion to add a little formaldehyde malin.'

EXPERIMENT WITH CONDENSED MILK.

Experiment 1.

To analyse a sample of condensed milk.

h out accurately about 20 gms. of the sample of condensed d then make up to 100 ccs. with water. Then proceed in e way as described for milk. To determine the percentage sugar in a sweetened condensed milk add together the per- s of protein, lactose, fat and ash and deduct this from the age of the total solids.

EXPERIMENTS WITH DRIED MILK POWDERS.

Experiment 1.

determine the percentage of moisture and mineral matter.

h out accurately in an evaporating basin of known weight gm. of the dried milk powder. Heat to constant weight ing oven and from the loss of weight calculate the percentage ure. Finally incinerate the sample and weigh the residue ral ash. Calculate the percentage of mineral matter.

Experiment 2*.

To determine the percentage of fat.

The Soxhlet extraction method already described may be
but the method is liable to give rather low results.

Experiment 3*.

To determine the percentage of protein.

Use the Kjeldahl process described on page 86 with 1 gra
the sample.

Experiment 4*.

To determine the percentage of lactose.

This is best determined gravimetrically by the Fehling's sol
method. Provided the mixture has been properly cl
beforehand the volumetric method using Fehling's solution
described on page 58 can be used.

EXPERIMENTS WITH BUTTER.

Experiment 1.

To prepare a sample of butter.

Allow a sample of cream to ripen by keeping it for several d
Place the ripened cream in a wide mouthed bottle or a hand ch
and shake or churn until separation into butter and buttermilk ta
place. Pour away the buttermilk, add water and re-shake or re-ch
for a few minutes thoroughly to wash the separated fat. Remove
fat after washing, add a small quantity of salt and work in a coher
mass with wooden butter pats.

Experiment 2.

To determine the percentage of water in a sample of butter.

Heat some of the butter in a wide mouthed 8 oz. bottle fitted w
a ground in glass stopper greased with some of the butter, o
water bath until the butter begins to soften and melt, taking c
not to overheat the butter and cause separation into water a
curd. Shake the bottle until the butter resembles thick cre
Now pour about 4 grams of the softened butter into a previou
weighed butter dish fitted with a ground in glass lid. Replace t
glass lid quickly and re-weigh. The increase in weight gives t
weight of butter taken. Remove the lid again and place the d
with its lid by its side in a steam oven in a slanting position, o
glass rod. The water collects underneath the molten fat and
evaporation is greatly facilitated by having the dish in a tilt
position and giving it an occasional shake during the early sta
of the heating.

about two hours, or when no milky white globules of water ble under the fat, take out the dish and its lid, cool in a or and weigh. Replace the dish and lid in the oven, for a period, re-cool and re-weigh until the weight is constant. he loss in weight calculate the percentage of moisture.

Experiment 3.

To determine the percentage of fat in a sample of butter.

about 30 ccs. of ether to the dried residue from the previous ent, stir well with a glass rod and allow to stand. Decant ereal solution of fat into a previously weighed evaporating taking care that no particles of curd or salt are removed. several times with more ether until all the fat has been ex- . Place the dish and its content in a steam oven to drive es of ether, and then weigh with its lid. The loss in weight ed with that at the end of the previous experiment gives the of the extracted fat. By subtracting the weight of the dish lid the combined weight of salt and curd is obtained. As on the weight of extracted fat the ether of the ether extract evaporating can be driven off on a water-bath and the fat then weighed.

Experiment 4.

determine the percentage of salt in a sample of butter.

the residues of curd and salt from the previous experiment evaporating basin with about 100 ccs. of hot distilled water. to cool and then add a few drops of potassium chromate n. Now titrate with N/10 silver nitrate solution from a until the red colour of silver chromate is permanent. The t of salt can then be calculated from the fact that 1 cc. $AgNO_3$ = 0.00585 gm. of sodium chloride.

Experiment 5.

determine the percentage of curd in a sample of butter.

ract the weight of salt determined in Experiment 4 from the ed weight of salt and curd obtained in Experiment 3, and alculate the percentage.

cessary the aqueous solution in Experiment 3 can be filtered a tared filter paper before titration with silver nitrate. well to remove any salt on the filter paper and then dry the aper in a drying oven and re-weigh. The increase in weight e the weight of curd. By subtracting this from the previously d combined weight of curd and salt the weight of salt deter- in experiment 4 can be checked.

Experiment 6.

To test butter for the presence of preservatives.

preservatives, other than salt, are prohibited. Should any ative be present it is most likely to be either boric acid or a

borate, the test for which is as follows:—Melt a portion of the
about the size of a pea in an evaporating basin, acidify with
drops of dilute hydrochloric acid and add ten drops of tur
solution. Stir the mixture with a glass rod and place on a w
bath. In the presence of boric acid or a borate a red colour
will develop round the edges as the butter dries. This ca
confirmed by the change of the red colour to a greenish-blac
the addition of ammonia.

Experiment 7.

To test butter for artificial colouring matter.

Colouring matter, either an azo dye or annatto, is occasio
added to butter during churning or blending to give the resu
product a richer and more pleasing appearance. Such added co
ing matters are best detected by Dolittle's methods.

(a) Azo dye. Place about 2 gms. of the filtered butter fat
test-tube and add a few drops of ether to prevent solidificatio
cooling. Add about 1cc. of dilute hydrochloric acid (1 in
Shake well and allow to stand. In the presence of an azo dy
pink colouration is developed in the acid.

(b) Annatto. Place about 2 gms. of the filtered butter fat
test-tube and add a few drops of ether to prevent solidificatio
cooling. Add about 1 cc. of 10 per cent. caustic soda or ca
potash solution, shake well and allow to stand. In the presenc
annatto a yellow colouration is developed in the alkali which t
pink on treatment with stannous chloride.

The same tests are used to detect colouring matters in margari

Experiment 8*.

To test for lipochromes (carotene) in butter.

Saponify 5 grams of butter with 50 cc. N 1 KOH. Cool and
tract the unsaponifiable residue with ether, using a separa
funnel, repeating three times. Wash the three combined extr
with water, dehydrate the ether extract by using 10 grams of
hydrous sodium sulphate. Decant the extract. Test for l
chromes (mainly carotene) by allowing drops to dry on a gl
porcelain tile, and then adding a drop of concentrated Nitric a
ii. concentrated sulphuric acid and KI—Iodine solution. T
reagents give a blue or blue green colour with carotene and xan
phyll.

If the experiment is repeated, but using cod liver oil instea
butter, the purple colour given with strong sulphuric acid is al
certainly due to Vitamin A. Vitamin A is more quantitati
tested in cod liver oil by replacing sulphuric acid with arseni
antimony chloride (2 cc. with one drop of cod liver oil in a test tu
The blue colour is quickly developed, but also fades quickly.

Experiment 9.

To distinguish between butter and margarine.

Note the taste, smell, general appearance and fracture. ually it is possible to distinguish between butter and mar- y these simple tests only, but not in the case of a margarine ontent of highly flavoured butter.

Foam test.

about 5 gms. of butter in an evaporating basin and the same f margarine in a similar evaporating basin. Warm both as nearly as possible equally. The butter usually boils vith a considerable amount of foam and the curd spreading e surface. The margarine usually takes longer to melt, h more " bumping " and spluttering, and the curd is liable t in a lump. Of the two, the butter usually burns more

also the smell of the boiling fats after withdrawal from the Butter gives off the characteristic smell of butyrin, while ne has a more tallowy aroma.

Valenta test.

into two test-tubes equal volumes of melted butter fat and margarine. Add to each equal volumes of acetic acid. oth test-tubes well and then place both in the same beaker and heat. Place a thermometer in the water of the beaker e the temperature at which the contents of the test-tubes clear after shaking. Butter usually clears between 30° and margarines consisting of vegetable oils clear at once, while nes containing animal fats remain turbid almost up to 100°.

Place equal amounts of butter and margarine in test-tubes l equal amounts of fresh milk to each. Warm each gently e fats are melted and then shake each thoroughly. Finally der the tap. Butter will blend and give a homogeneous . Most margarines do not blend but separate out in lumps

Place small pieces of butter and margarine in test-tubes and mall amount of alcoholic solution of caustic soda to each. ff most of the alcohol by placing the test-tubes in boiling Allow to cool and then add hydrochloric acid to each. will give off an unpleasant odour of butyric acid. In the the margarine the smell of butyric acid will be hardly ble.

EXPERIMENTS WITH MARGARINE.

Experiment 1.

To analyse a sample of margarine.

determinations of the percentages of water, fat, salt and curd ried out by the same methods as described for butter. The r colouring materials and preservatives are also the same.

Experiment 2.

To test for the presence of cotton seed oil (Kalphen's test).

Place about 3 ccs. of the margarine in a test-tube and ad equal volume of amyl alcohol and the same volume of a 1 per solution of sulphur in carbon bisulphide. Plug the mouth of test-tube with cotton wool and heat in boiling water for 30 mi in a fume cupboard. N.B.—The tube is liable to burst or the blow out; carbon bisulphide vapour is extremely inflammab

The appearance of a crimson colour is an indication of the pres of cotton seed oil. It should, however, be remembered that co seed oil which has been heated above 250° C. (or has been hydro ated) does not give this test.

Experiment 3.

To test for the presence of sesame oil (Baudouin's test).

Shake together 10 ccs. of melted margarine fat with 10 ccs concentrated hydrochloric acid (sp. gr. 1·19) in a separating fun Allow the mixture to stand until it separates into two layers the lower layer of acid is strongly discoloured draw it away and sh the fat with a second 10 ccs. of concentrated hydrochloric a Again allow to settle and if the lower layer of acid is now clear four drops of a 1 per cent solution of furfurol in alcohol and ag shake. On standing a crimson colour is developed in the acid la if the oil under examination contains even as little as 1 or 2 cent. sesame oil. It should be remembered that if the marga contains an azo dye it will give a pink colouration with the hyd chloric acid before the addition of the furfurol.

Kalphen's test for cotton seed oil and Baudouin's test for sesa oil, can of course be applied to other fats and oils.

EXPERIMENTS WITH CHEESE.

Experiment 1.

To investigate the food materials present in cheese.

Test the given sample of cheese for food constituents. Red some of the sample to ash, determine its constituents and note reaction. Test both cheese and rind for preservatives.

Experiment 2.

To illustrate various methods of cooking cheese.

Grate a quantity of cheese and place equal weights of the gra cheese in three similar evaporating basins. Heat the first sam alone over a small flame taking care not to burn it. Add suffic

the second sample to cover it, and heat over a small flame.
ficient milk to the third sample to cover it and heat on a
ath.

nine the sample after heating and draw conclusions as to
s of cooking cheese.

Experiment 3.

To show the action of warm potassium bicarbonate solution on cheese.

small quantity of grated cheese in a test-tube add a very
warm solution of potassium bicarbonate. Shake thoroughly
te the result. What bearing has this experiment on the
of cheese? Explain the effect of cooking on cheese.

CHAPTER XVII.

MEAT.

Meat consists primarily of muscular tissue, with amou of fatty tissue varying not only with the cut or joint also with the animal, its species, age and feed, being in lean and young meat and high in the flesh of anim intensively fed for the market. In addition, meat variably contains connective tissue which binds the dividual muscle fibres together and in places is mas into gristle or tendons, linking muscle with bone cartilage. Nerves and blood vessels—arteries, capilla and veins, the latter usually containing a little bloo are dispersed throughout the flesh. A chop or joint bought and cooked usually has in addition a fair p portion of bone or cartilage. These several tissue other than fat—are composed for the most part of vari proteins. The proteins of connective tissue and cartila (collagen, etc.) are comparatively simple, and yield hydrolysis by prolonged boiling, gelatin and simi substances. The protein of living muscle consists larg of myosinogen and para-myosinogen; these clot after de at ordinary temperatures to form a firmer substan myosin, and set up the state of *rigor mortis*. Presen the coagulated myosin is liquefied, perhaps as a res either of acidification due to liberated sarcolactic ac or of autolysis by the enzymes secreted from the c protoplasm. The flesh becomes soft again and liable further profound changes by invading micro-organis and its own proteolytic enzymes. During the stages maturation a certain amount of solution of the prote takes place, making them more digestible on cooki When the muscle proteins are heated to about 60° as in the process of cooking, they coagulate and the m becomes firmer and more easily masticated, even if it made a little less digestible.

Associated with myosin are small quantities of other pro which dissove in cold water, as from minced meat when ex

l but kept below the temperature of coagulation. The pro- beef tea is largely of this type. Hæmoglobin derived from od vessels gives meat its usual red colour; it is not very ble.

landular tissues, where high metabolic activity is the rule, proportion of the substance consists of cell nuclei, which h in nucleo-proteins. This group of proteins on hydrolysis gestion differs from most other proteins in yielding purine unds—such as xanthine and uric acid. Among the structures this group of proteins are sweetbread (thymus), collop eas), lamb's fry and fish roes, and to a less degree liver and s. This class of food has a flavour and taste quite different rdinary flesh meat. The ultimate purine derivatives are ted through the kidneys with greater difficulty than the nd its allies produced from ordinary proteins, and are ive to rheumatism and gout.

ddition to proteins meat contains small quantities of other nous substances which are distinguished as non-proteins and ives. "Non-protein nitrogen" is an analytical term which ses the soluble proteoses, polypeptides and amino-acids ed in the progress of enzymic autolysis during maturation at. Though these are not strictly proteins, they are early tives of proteins by way of hydrolysis and may be fairly ed as such dietetically. The term "extractive nitrogen" s all the soluble products of the latest stages of nitrogen lism, such as urea, creatine, soluble purine and allantoin, as the flesh bases, sarcosine and carnosine. These substances o food value of any sort, but it is to them functioning as ants that the digestive value of the common meat extracts

Non-nitrogenous extractives, which like the other class eadily into water, when cold or hot, are sarcolactic acid, en (animal starch), and various mineral salts. Beef contains le some one per cent. of these salts, and three per cent. when ed in the dry state. The commoner elements represented in n of meat are sodium, potassium, calcium, magnesium, iron, horus and chlorine.

VALUE EAT. The primary importance of meat as a food lies in the fact that when digested its protein is reduced to its ultimate amino- which when assimilated by the system suffice as ng units for the repair of all types of cells and s, and the formation of new growth. Muscle n is of the highest class and provides, among other o-acids, tyrosine, lysine and tryptophane, which are ial to growth and life. It is quickly digested in the ch—a matter of 3-4 hours according to the character

of the meat—and is almost completely absorbed in intestines, little being rejected in the fæces. Natur muscle protein is the best sparer of tissue protein, which, taken in the mass, it is for all practical purp identical. Gelatin, which is derived from the collage various types of connective tissue, in contrast, is a sec class or imperfect protein, for being deficient in tyro and tryptophane it is incapable by itself of tissue build although being rich in lysine and arginine it may sup ment other second class proteins, such as wheat gli in bread.

The fat generally associated with flesh may be regar as secondary to the protein, only in so far as it suffice a supply of energy and not as a tissue former; it is important ingredient of meat foods and supplies i well balanced diet the major portion of the fuel ene required by the body. The various classes of m extractives play an evident role in giving flavour, and palatability, to cooked meats and soups. They do contribute materially either to tissue building or fuel-energy, or even as assistants, or catalysts, in metabolic processes. The claims that meat extracti stimulate the heart muscles so increasing their action, the nervous system, including the brain, so diminish fatigue, or that they encourage the building up of tis out of all proportion to the amounts assimilated, ha all been examined critically and in the event rejected

The flesh of fish differs incidentally from that of ot food animals chiefly in the larger proportion of wat the relatively high proportion among the proteins gelatin, which is the reason for the marked loss in wei and bulk when fish is boiled, and the deficiency in extr tives with consequent insipidity. Fish are commo distinguished according to their proportion of fat, "fat" and "lean": among the former class are pla high, eel, salmon, mackerel and herring, and low am the latter class, cod, haddock and whiting. Reckon as fuel foods the former are good and may be che while the latter are poor and possibly dear. Th salmon, yielding 801 calories to the pound and bought

2s. 6d. is definitely cheaper than cod bought at 1s. ound and yielding 276 calories. The best bargain fish is the herring in its various forms, fresh, bloater and kipper, being rich equally in first roteins for tissue repair, and fat for energy. On ntrary such fish as turbot, sole and halibut are dear.

IINS Ordinary lean beef and mutton are poor in vitamins, except B_1 and Nicotinic acid ; C, D and E are missing. Cooked canned goods contain still less. The liver, sweetbread and ys are rich in vitamins ; the liver particularly in A, lavin and Nicotinic acid. The adrenal gland was ource from which ascorbic acid (vitamin C) was first ated in quantity.

MINS Lean or white fish being poor in fat is lacking in the fat-soluble vitamins, even more so than meat, but fat fish such as salmon and herring are rich in A and D. The livers of nd halibut are particularly rich in A and D, and oils ssed from them are the chief supplies of these nins.

COMPOSITION AND ENERGY VALUES OF MEATS.

(After R. H. A. PLIMMER.)

Beef.

	Percentages.					*Calories per lb.*
	Water	*Ash*	*Protein*	*Carbo-hydrate*	*Fat*	
steak (Lean)	71·6	1·2	22·1		4·9	617·8
(Lean)	66·9	0·8	21·5		10·1	826·0
y	76·3	1·3	18·1		2·6	446·3
... ...	70·8	1·6	19·9	4·4	3·2	587·0
... ...	5·9	0·2	1·2		93·3	3,958·1
eas (Lean)	73·0	1·8	17·6		7·3	635·5
us	70·8	1·8	17·0		11·0	780·2

DETAILED ANALYSIS OF BEEF.

Beef Steak (Lean only)		grams.
	Total Nitrogen per 100 gr. ...	3·19
	Purine do. do. ...	0·058
	Non-Protein Nitrogen.	
	Amino nitrogen per 100 gr. ...	0·127
	Extractive ditto ...	0·137
	Protein per 100 gr.	19·3
	Fat ditto	10·5

Beef Steak	Na.	K.	Ca.	Mg.	Fe.	P.	Cl.
	(mgs. per 100 grs.)						
	69	334	5·4	24·5	4·3	276	70·1

Mutton.

	Percentages.				*Calories per lb.*
	Water	*Ash*	*Protein*	*Fat*	
Leg (Lean) ...	70·8	1·1	21·1	7·0	687·7
Loin (Lean) ...	65·8	1·0	21·6	11·8	899·5
Neck (Lean) ...	54·2	1·0	17·4	25·6	1,403·4
Shoulder (Lean)	69·4	1·0	19·5	9·6	767·5

Pork.

	Percentages.				*Calories per lb.*
	Water	*Ash*	*Protein*	*Fat*	
Leg (Lean) ...	73·8	1·0	19·3	6·0	611·9
Loin (Lean) ...	66·0	1·1	21·4	11·1	806·4
Shoulder (Lean)	63·3	1·0	19·7	15·9	1,036·9

Bacon.

	Percentages.				*Calories per lb.*
	Water	*Ash*	*Protein*	*Fat*	
Side of Bacon					
i. Back (Lean) ...	54·9	1·8	19·3	11·6	848·2
ii. Gammon (Lean)	60·8	2·6	19·1	6·4	625·1
iii. Shoulder (Lean)	49·5	1·7	17·7	21·7	1,244·7
iv. Streaky (whole)	27·0	3·6	10·3	54·2	2,478·0
Ham, Edible (whole)	31·0	1·3	10·65	40·4	1,904·7

Fish (Uncooked).

	Percentages.			*Calories per lb.*
	Water (& salts)	*Protein*	*Fat*	
... ...	85·3	14·6	0·1	276
Dried)	17·72	81·54	0·74	1,828
ck (Fresh) ...	87·8	12·0	0·2	232
rel	82·8	11·0	6·2	466
g (Fresh) ...	76·6	14·6	8·8	643
g (Bloater) ...	75·7	15·3	9·0	662
g (Kipper) ...	74·8	14·1	11·1	730
n	72·8	14·7	12·5	801
... ...	76·2	8·7	15·1	799

rvation eat. The decomposition of meat is brought about by micro-organisms, i.e., bacteria and moulds, and by the enzymes nually secreted by the living cell protoplasm. It therefore be stopped by the elimination of invading o-organisms, and the inhibition of the enzymes. ractice both ends are served by identical treatment. t may be preserved by any of the following nods :—

Drying or desiccation in hot sunshine, hot air or es from burning wood, etc. ; as dried beef, jerked meat mican. The dehydration of meat is now in process considerable development.

Heat treatment, killing most organisms and enzymes. vas noticed as long ago as 1765 that meat extract d and sealed in flasks did not undergo decomposition. observation led to the development of the canning stry. To-day meat is cut into pieces of appropriate l size and is then parboiled and placed in tins ; meat is added, and the tins are closed and processed. canning calls for especial care, because of the extreme lity of fish to bacterial pollution and decomposition. h fish only should be used and the processing should horough.

Cold treatment in which the meat is either chilled ozen, so that the action of both bacteria and enzymes

is inhibited. Two methods of cold storage of me goods are used: (i.) Chilling, at just above the freez point of water, and (ii.) Refrigeration, by which the me is actually frozen. During chilling at 1—2°C., the activ of bacteria and enzymes is not completely stopped, b only slowed down; a small amount of water is lost evaporation. In freezing, the crystallisation of the wa as ice separates the fibres of meat and leaves them in shrivelled state. In thawing, if the process is carri out sufficiently slowly the fibres re-absorb the water a regain their original appearance. During this stag however, bacterial change makes considerable progres Rapid thawing gives a darker and moister product tha fresh or chilled meat. Water lost in the 'drip' contain many soluble food substances of the meat. Frozen mea should therefore be allowed to thaw slowly, and be cooke as soon as it is completely softened, before decompositio has fairly started. The best results are obtained by ver rapid freezing at –20° to –45° C., resulting in the forma tion of very small ice crystals inside the substance of th meat proteins. In slow freezing the ice forms in larg crystals which rupture the fibres as they grow. Frozen meat, besides being more easily handled than chilled meat will keep fresh practically indefinitely, so far as bacteria change is concerned, although the chemical and physica properties of the proteins undergo change affectin its power of holding water. The value of beef is greate when it is imported chilled and not frozen, since it is ready for immediate sale, is well conditioned and tender, and little different from home-killed beef; its drawbacks are occasional bacterial and mould growths, and rancidity and colouring of fat. Until recently it was not possible to maintain chilled meat in transport and storage in good condition for longer than a month or so—a fact which was convenient to the Argentine meat industry. Latterly it has been discovered that beef can be stored in the chilled state for 60-70 days when the atmosphere contains 10 per cent. of carbon dioxide, a period which is sufficient for the conveyance of carcasses from Australia and New Zealand.

Refrigeration has been recently applied to the herring

industry. Herrings although containing much fat than white fish can be brine-frozen at −20° C., ter five months' storage be made into good kippers. salmon from British Columbia has long been on arket.

reservation by chemicals. The commonest chemical n the case of meat and fish is ordinary salt. Its ptic power is dependent upon its direct destructive on many organisms, and also to a much greater upon its high osmotic power in plasmolyzing cells generally withdrawing water from tissues. The h of moulds and many undesirable bacteria is ed by 2.5—3.0 per cent. salt; the destruction of oisoning bacteria requires a 15—20 per cent. con- tion. Saltpetre is often used in conjunction with n curing meat and fish; in reaction with organic produced by bacteria it forms small quantities of s and nitric acids which rapidly stop bacterial . The fact that saltpetre appreciably slows down ion by artificial gastric juice, however, makes its s a preservative doubtfully beneficial.

sage meat is sometimes treated with sulphurous and sulphites as preservatives, but their use is ded with a risk of gastric derangements.

servation by wood smoke, as of bacon, kippers, and fish generally, is a very old method of preservation is quite effective. It acts partly by closing the on the surface and forming a fairly impenetrable r to bacteria, and partly by the absorption of vol- phenols and acids that are definitely bactericidal. ner preservatives are several organic acids—lactic, , butyric and succinic acids—which act by virtue eir acidity, for the powerful putrefactive bacteria sh only in alkaline media.

ning. The main types of food poisoning are as follow.

By foods naturally poisonous.

ds or fruits containing alkaloids, such as deadly shade and aconite, or prussic acid as in bitter

almonds, may occasionally be eaten and cause poisoni but these are out of the way examples. Rabbits m however eat poisonous food of this sort without a apparent hurt to themselves, and yet their flesh may sufficiently charged with poison to give rise to seric symptoms of poisoning when eaten.

2. **By foods containing poisons accidentally or purpose introduced.**

The study of purposeful introduction falls proper within the scope of forensic medicine and criminolog Under ordinary domestic conditions there is howev the risk of metallic poisoning; as for example, by t verdigris or copper salts formed by the prolonged actio of fruit acids and vinegar on copper or brass cookin utensils, or by the solution of enamel in hollow-ware con taining antimony by such organic acids as vinegar, citri acid of lemon water and oxalic acid in rhubarb It would not appear that there is any serious dange in the use of aluminium utensils for the preparation o food, so long as alkalis, which dissolve aluminium, ar absent.

3. **By foods containing toxins**—the poisonous product of bacterial action.

It is probable that slight poisoning of this type i relatively a common occurrence. Early in the course o the investigation of this class of poisoning unstabl poisonous substances were isolated, and termed "pto maines." These were thought to be responsible for the usual effects and, although this idea has been since disproved, "ptomaine poisoning" is still a popular term As a matter of fact ptomaines are not developed until an advanced stage in the decomposition of foods is reached and also, like snake poison, when taken by the mouth they are harmless. Food poisoning has been proved to be in the main due to a group of bacilli, the Salmonella group or the Gaertner bacilli, which are responsible for about 75 per cent. of the cases. The bacilli grow rapidly in food, especially in warm weather, causing no change of colour, odour or taste, but producing as by-products

which are very irritant and bring on acute in-
tion of the intestinal tract in five to six hours.
particularly liable to infection are manipulated
.g., foods which are heated and cooked slowly, such
ed foods and made-up meats: fresh meat or fish
ay become infected in transport or handling.
ng-up is not fatal to these bacteria unless the food as
d is well cooked before heating. During the
ing of canned foods while bacilli are often
ed their toxins being heat resistant are not affected.

her example of food poisoning of this type is
m. The features are very characteristic; there
g delay of symptoms, and these are chiefly nervous,
g the eyes and throat and closely resembling
e poisoning. At first recognised in Germany from
meat, there have been occasional outbreaks in
ited States due to canned goods, often vegetables,
this country due to meat paste, etc. It is very
: in the outbreak at Loch Maree in 1922 eight
s died from botulism contracted from one single
wild duck paste used in making sandwiches. It
sed by a true bacterial toxin from a specific an-
organism—Bacillus botulinus. This is easily
ed by heat, but the toxin is poisonous in very
amounts both by ingestion and injection: it is
accompanied by the odour of rancid butter.
urce of infection is often difficult to discover, although
e instances it would appear to be in the soil of
lar districts; for which reason the manufacture of
goods is prohibited in certain territories in the
l States.

By foods containing pathogenic bacteria.

lthy meat would seem to contain few if any bacteria
hological significance. Of course it is otherwise
diseased meat, which may unfortunately escape
tice of the meat inspectors and pass into consump-
Chopped meats and sausages are liable to infection
ge numbers of bacteria. Microbes may be also
itted by human carriers: among them, those of

typhoid, scarlet fever and diphtheria. A man who recovered from any of these diseases may still carry broadcast their germs; particularly if in the course of occupation he is concerned with the handling of fresh made-up meat or milk. Flies are notorious as conveyors of putrefactive and pathogenic germs, and rats and mice have also been held accountable for the infection of prepared foods in larders or cook-houses, resulting in outbreaks of food poisoning.

ANIMAL FOOD EXPERIMENTS.

MEAT AND FISH.

Experiment 1.

Preliminary Examination of Meat and Fish.

Examine a small piece of raw beef, mutton or pork. Note the colour, consistency, smell and feel. Press upon it pieces of red and blue litmus papers and note the reaction.

Fresh sound meat should be red in colour, not pale pink or purple, and should have a marbled appearance owing to the presence of small veins of fat among the muscle fibres. It should be firm and elastic to the touch and should hardly wet the fingers. The smell should be very faint and pleasant. The reaction of the meat should be acid.

Examine a small piece of cod in the same way and compare.

Now boil the samples of meat and fish for a few minutes.

Remove and examine with a good lens. Note the muscle structure, the bundles of muscle fibre, the connective tissue and any interstitial fat.

Experiment 2.

To identify the food materials present in meat and fish.

Test small samples of meat and fish for the presence of proteids, fat, starch and sugar, by the methods already given under these headings.

Experiment 3.

To determine the percentage of moisture in lean meat and fish.

Weigh out between 2 and 4 grams of finely chopped or minced meat or fish into a weighed evaporating dish. Dry in a steam oven to constant weight and calculate the percentage of moisture.

Experiment 4.

ermine the percentage of mineral matter in lean meat or fish.

the sample of dried meat or fish from the previous experi-
til an ash of uniform colour is obtained. Cool in a desiccator
gh. From the weight of ash calculate the percentage of
matter. Attempt to identify the chief mineral constituents
sh by the methods outlined on page 128.

Experiment 5.

To examine the chemical composition of bones.

small pieces of clean bone in dilute hydrochloric acid of
0 per cent. strength for several days. At the end of this
nove the bone and examine it. Evaporate the liquid to
and then ignite the residue with gentle heat. Dissolve
due in very dilute hydrochloric acid and test for phosphate
cium.
the significance of this experiment in connection with the
ion and properties of kitchen stock.

Experiment 6.

To show the effects of boiling upon meat.

lace a piece of lean meat in a beaker of *cold* water and heat
Note the changes which take place and determine by
of a thermometer at what temperatures they occur. At
8° C. the water becomes cloudy in appearance owing to the
tion of the soluble proteins (soluble globulins, albumins,
s and peptones) which have dissolved out of the meat.
t 71° C. most of the coagulated proteins rise to the surface
ownish scum and the lower liquid becomes much clearer.
he temperature reaches boiling point, let it simmer gently
t half an hour. Remove the meat and examine it. Note
r and taste and the ease with which the muscle-bundles
orn apart.

lace a similar piece of lean meat into a beaker of *boiling*
nd note the effects as the heating continues.

a few minutes, lower the temperature of the water to between
85° C. and maintain it at this temperature for about half
.

e that this time the water does not become cloudy, as it
he previous experiment, and that the amount of scum which
the surface is considerably smaller. Remove the meat
mine it. Note the colour and taste. Note that the outside
owing to the coagulation of the proteins and acts as a pro-
crust or coating. Cut the meat open and notice that the
still juicy.

Note the significance of these experiments, as illustrating the results of various methods of cooking meats. What method of cooking should be adopted to give :—

(a) A rich broth or soup

(b) A juicy well-flavoured meat ?

Experiment 7*.

To examine a commercial meat extract.

Add some of the commercial meat extract to cold water in a beaker. Stir and leave to stand for an hour. Filter. Note the quantity of insoluble material on the filter paper and examine any such material under the microscope. Are meat fibres present ?

Add a few drops of concentrated acetic acid to the filtrate and bring to boiling. Does coagulation occur ? Coagulation is an indication of the presence of albumins.

Filter again, and to a portion of the filtrate add two or three drops of dilute sulphuric acid and then saturate with finely powdered zinc sulphate. Stir well, and allow to stand for at least an hour. Note whether any precipitate separates out. Such a precipitate consists of proteoses and gelatin.

To the remainder of the filtrate add a few drops of hydrochloric acid to convert any creatin present into creatinine. Add caustic soda solution until the mixture is distinctly alkaline. Allow to stand for five minutes and then add an equal volume of a saturated aqueous solution of picric acid. A deep orange colour is an indication of the presence of creatinine formed from creatine in the meat extract. Yeast extracts which are sometimes used as substitutes for meat extracts do not contain creatine.

Experiment 8.

To examine a meat product such as sausages or potted meat.

(a) To detect starch (bread crumbs, flour, etc.).

Boil a portion of the sausage meat or potted meat with water in a beaker. Allow to cool and test a sample with a solution of iodine in potassium iodide. Blue colouration will indicate the presence of considerable amounts of starchy " filler."

Small quantities of added starchy materials can be detected by teasing out a small amount of the sausage or potted meat on to a microscope slide, adding a drop of iodine solution and examining under the microscope. Pepper grains should be looked for during this microscopic examination as well as cereal starch cells.

(b) To detect artificial colouring material.

Finely divided meat, such as is present in sausage and potted meats, rapidly changes in colour, and saltpetre or sulphites as

es used to delay this. Alternatively, oxide of iron (red
niline dyes or cochineal are sometimes added to mask the
n colour.

d Ochre. Heat some of the sausage meat or potted meat to
n a crucible. Examine the ash carefully. If it shows a
brown colouration a considerable proportion of iron oxide
re) is present.

niline Dye.- Soak some of the sample in 50 per cent. alcohol
quent stirring for several hours. All natural colouring should
lved out by this treatment. Any remaining colour indicates
oable presence of artificial colouring material.

this alcoholic extract, concentrate it to half volume on a
ath and acidify with hydrochloric acid. Place a strand of
ool in the liquid and heat to boiling for several minutes.
hether the wool is coloured or not. A distinct colouration is
cation of an aniline dye. To verify, remove the wool and
n very dilute hydrochloric acid and then in water. If the
persists an aniline dye is present.

Cochineal.—Soak some of the sample in water for some time
equent stirring. Filter and acidify the filtrate with hydro-
acid. Place in a separating funnel and shake with amyl
Allow to stand until two layers are formed. Separate the
cohol layer. In the presence of cochineal the amyl alcohol
slightly yellow in colour. Add ammonia. The production
let colouration indicates cochineal.

Detect preservatives (Boric acid, borates or sulphites).

oric acid or borates.—Boil a mixture of the sample with
or a few minutes. Filter, after cooling. Acidify the filtrate
drochloric acid and test with turmeric paper.

ulphites.— Prepare a test-paper by treating a piece of filter
with starch solution and then with a solution of sodium
containing citric acid. Bring the paper into close contact
e sample of sausage meat or potted meat. Any sulphite
will decompose the sodium iodate on the paper with the
ion of iodine which will give a blue colouration with the

CHAPTER XVIII.

EGGS.

By the term eggs we ordinarily mean the eggs of t domestic fowl, but these are not the only edible eg The eggs of ducks, geese and turkeys as well as those such wild birds as the plover, gull, and heron have been used as human food; other eggs used as food a those of the turtle and many varieties of fish, e.g., sturge (caviar), and herring (roe). For our purpose we sh confine ourselves to the hen's egg, which constitutes t chief source of our supply of eggs.

STRUCTURE. It will materially assist our understandi of the structure of an egg if we realise at t outset that it is a living organism consisting of an embry or germ and its store of food enclosed in the protecti shell. Everything about an egg is wonderfully designe by nature to ensure the safe development of its livi embryo into a young chick, able to step out of the she into the outside world and capable of very largely fendi for itself.

The hen's egg is ovoid in shape, one end being narro and the other broad and blunt. This shape has severa advantages. It prevents the egg from rolling far fro the nest, since it rolls in a circle if accidentally move This is particularly important in the case of eggs laid o the ground or on narrow cliff ledges as those of sea fow The ovoid shape also helps the close packing of the eg in the nest, and materially increases the resistance of th shell to external pressure.

The shell consists chiefly of chalk (calcium carbonate with small quantities of calcium phosphate and organ matter. The shell is porous to allow the passage of a into the interior of the egg; it is through these pore that the living embryo and the developing chick obtai the necessary oxygen for respiration and through whi

surplus carbon dioxide. Unfortunately also this character of the shell allows the entry of bacteria egg, which cause the putrefaction of the contents. eath the shell is a thin parchment-like membrane, t the broad end of the egg divides into two layers n an air chamber. Inside the shell membrane are white " and the " yolk." The yolk is a golden fluid mass enclosed in a thin elastic membrane, herical in shape. The yolk contains the germinal living embryo, which can be seen in a fertile egg as l circular speck underneath the yolk membrane. r the yolk nor the white is of the same consistency hout. The yolk is least dense near the embryo, e viscous transparent white is thickest round the nd develops into two twisted fibrous cords known alazas," or balancers. The fact of the yolk being in the region of the embryo ensures that the o will be uppermost and nearest to the heat of the body. Should the egg be moved the fibrous bal- allow the yolk to revolve slowly inside the egg he embryo is again uppermost.

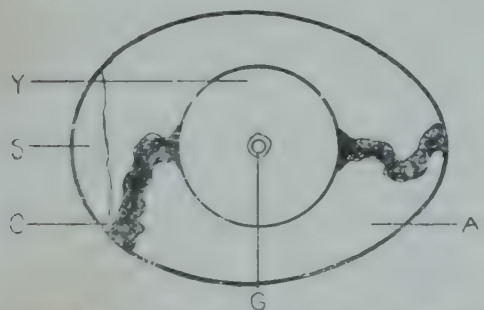


Diagram of a fowl's egg. A. albumin or egg white. C. chalaza. G. germinal disc or embryo. S. air space. Y. yolk.

GHT AND OSITION GS.

The average weight of a hen's egg is 55·8 grams or about 2 ounces, and its approximate composition is as follows :—

l and membrane 10·1 per cent., White 59·7 per Yolk 30·2 per cent. Without the shell the pro- ns of white and yolk work out at : White, 66·4 per

cent. and Yolk 33·6 per cent., so that there is a... exactly twice as much white as yolk.

The following table gives the detailed composition a hen's egg :—

	Water	*Protein*	*Fat*	*Ash*	*Undetermined*	*Calo...*
	per cent.	*per cent.*	*per cent.*	*per cent.*	*per cent.*	
Whole Egg (without shell)	73·7	12·3	11·26	1·1	1·64	734
White	87·2	10·7	0·1	0·6	1·4	229
Yolk	47·1	15·5	33·3	2·0	2·1	173

It is obvious from this table that the yolk is great... superior in food value to the white.

The white of egg or egg albumin is essentially prote... in character. Almost the whole of egg white is made u... of a single protein known as ovalbumin in the form of... solution enclosed in a cellular structure. The yolk ... much richer and more complex in character. It contain... much less water, more protein and a high proportion ... fats. In addition to ovalbumin, egg yolk contains th... phosphorised protein, vitellin, the phosphorised fa... lecithin, the alcohol, cholesterol, and a non-nitrogenou... substance, cerebrin. The fats of yolk consist of ole... and stearin with small amounts of palmitin. Th... mineral salts contain valuable calcium and iron com... pounds. The characteristic colour is due to the presen... in it of the colouring material lutein. Many of the... substances are valuable nerve building foods and explai... the use of eggs as constituents of proprietary nerve tonic... The deficiency in carbohydrates is usually made up i... ordinary diets by eggs being eaten with bread or potato...

Eggs are fairly rich in all the vitamins except Nicotin... acid and C: A, B_1 and B_2 in the fat, and D with th... cholesterol of the egg yolk.

In spite of the greater food value of egg yolk it do... not command so high a price as egg white when the tw...

separately. This is because of the beating powers white (see page 195), in which the egg yolk is de- It should be remembered however that egg yolk uable ingredient in baked goods on account of the lour it imparts and its enriching, flavouring and ing action. The best results are obtained when le egg is used for confectionery purposes. Gener- eaking, whole eggs are capable of aerating an eight of flour.

The digestion of raw eggs begins in the stomach and is completed in the small intestine. New laid eggs are more easily d than eggs which are several days old, but the asily digested form of egg is one which has been boiled. A hard-boiled egg is very much more to digest than either a raw egg or a lightly boiled he same remark applies to other methods of cooking, ying, scrambling, poaching, etc. By whatever an egg is cooked the result is always the same— gulation of the proteins. This coagulation begins C. (133° F.), so that fully boiling water (100°C.–) is not essential to the "boiling" of an egg.

In addition to their use directly as food and as aerating and enriching agents in sponge and cake mixtures, eggs are used in omelettes, ds, Yorkshire and other puddings, etc. Whites ed separately in such as meringues, macaroons, cing and certain types of biscuits. Egg yolks are used alone, for the fats they contain have a tough- ction if present in appreciable quantity.

When eggs are to be kept for some time they should be placed in a suitable tray with the blunt end containing the air chamber upper- In this way the yolk is kept in its proper position, nded by the white: the white is less likely to rate into the condition known as 'watery' white. hite has a bactericidal action, strongly putrefactive a disappearing from it on incubation: the yolk other hand is favourable to the growth of bacteria.

About 10 per cent. of ordinary eggs are infected in t
yolk. Eggs stored or packed in this way are less ea
broken and keep fresh longer.

TESTING OF EGGS. On account of their high nutritive qualities eggs are excellent medium for the rapid multiplication of bac which rapidly putrefy the food contents. The sul compounds of the albumin yield sulphuretted hydrogen as a composition product, and it is this gas which gives the distinct smell to a rotten egg. Another cause which renders eggs unsuita for human food is the partial development of the embryo owing irregular collection or accidental incubation. Since the egg enclosed in a mineral shell it is impossible to know by ordinary vi examination whether the contents of the egg are good or bad u the shell is broken when it is sometimes forcibly apparent that the are not as they should be. Some simple method of testing t quality and freshness of a whole egg is obviously desirable, and t methods are in common use. These tests are the brine test and t candling test.

(1) *Brine Test.*

This test consists in placing the egg in a 10 per cent. salt solutio (2 ounces of salt in a pint of water) in a tall jar, and is a simple an infallible test. A newly laid egg will sink in such a solution an lie flat at the bottom of the jar. An older egg has lost weig by evaporation of water through its porous shell, while the shrinka and drying of the contents enlarge the air chamber. As a resu the egg becomes lighter and more buoyant with age. A two-day-o egg will float near the bottom of the solution with its broad end u wards. A three-day-old egg will float about half way up the solutio and one five days' old or more will float on the surface. Thus th older the egg the nearer the surface it floats. While it is not alway possible to judge the exact age of an egg by this method, it is eas to decide whether the egg is fresh or not.

(2) *Candling Test.*

This method of testing the freshness of eggs is dependent up their transparency to light and not upon their buoyancy. It is quicker method and more suitable for large scale work than th brine test but requires skill and experience to obtain reliable result The apparatus consists of a lamp (oil, gas or electric) surrounde by a metal shade bored with a hole. The egg to be tested is held against the hole, slowly turned between finger and thumb, and th transparency of the egg observed. For home use a sample form candling lamp can be improvised by cutting a hole in a sheet stiff cardboard, placing the egg against the hole and holding th cardboard up to some source of light. Alternatively an ele bulb can be placed in a cardboard box and the egg placed in a ho in the lid.

ot sufficient merely to hold an egg near some source of
e ligl' can pass round the egg and obscure the test. Only
ally passing through the egg must reach the eye of the
When a new laid egg is tested by this method the white
lear and homogeneous. the air chamber is small and the
rose-tinted circle in the middle of the egg. In an older
white appears cloudy, the air chamber is enlarged and the
f a reddish tint. A rotten egg is opaque.

CATION Eggs are classified as follows. Firsts and Extras; freshly laid, sound, whole medium and large eggs with clean shells. Seconds: eggs, undersized cracked shells, leakers or dirty. Dirty eggs do not keep if washed their keeping quality is much reduced by the of the delicate film of mucus on the surface of the shell.

". "Spots" on eggs are due to bacteria, blood or mould growth. The term "spot rot" is applied to eggs in e germ is dead and decomposing. Moulds often develop old eggs being more susceptible to their growth than fresh he commonest moulds are the Penicillium glaucum and rium herbarum, but neither causes much, if any, putre- Bacteria on the other hand cause decomposition. "White wn in sour or addled eggs is in the first stage pale yellow ery. "Mixed rots" are in a more advanced stage, and yolk is rarely intact, the contents are thin and sour, and odours are given off. "Black rot" marks the last stage of sition, when the contents are very dark and appear mixed er, with a strong smell of sulphuretted hydrogen.

ATION The reasons for the preservation of eggs are not far to seek. The rapidity with which eggs putrefy, and the irregularity of supplies with the con- variation in price, are in themselves sufficient reasons for g eggs. The inadequate home supply of eggs in this makes it necessary to import eggs from such countries as , Ireland, Canada, Australia, New Zealand, Argentina, Siberia, Spain, France, China, Japan, and Egypt (Egyptian smaller—about 12 to the lb.). Further, the fragile nature hole egg and the large percentage of water it contains ransport difficulties and costs.

ethods for the preservation of eggs are:—by pickling vatives, by freezing and by drying.

This is the common method used in the domestic preserva- tion of eggs so that the eggs can be bought when they are and cheap, and used when they are scarce and dear. The eggs are placed in a solution of water-glass (sodium silicate) water. The pores in the shell are hermetically sealed teria are prevented from entering the egg. It must be red however that there are bacteria in the egg even before , so that some decomposition will take place. This de- ion will be very slow since the supply of air is cut off, and

only the anaerobic bacteria can multiply in the absence of ... A "pickled" egg will remain fit for use 9 or 12 months. W... "pickled" egg is boiled the shell almost invariably cracks, b... the pores of the shell are sealed, and the expansion of the air cha... during heating causes a sufficient internal pressure to break the ... The breaking of the shell can be prevented by making a small ... through the broad end of the egg into the air chamber by m... of a pin or needle.

PRESERVATIVES. A more suitable method for transport purp... is the addition of a preservative to liquid e... The eggs are broken into tins, thoroughly mixed together wi... preservative and the tin sealed. The presence of the preserva... prevents the multiplication of the bacteria in the mixture ... consequently arrests decomposition. The usual preservatives ... borax or formalin, both of which have the disadvantage of b... cumulative poisons, and neither of them prevents the breaking d... of the proteins present with the production of harmful prod... Eggs preserved in this way will remain fit for confectionery purp... for 6 to 8 months.

FREEZING. By keeping eggs at temperatures in the region of ... freezing point of water all microbial activity is arres... and no preservative need be added. The bacteria are not destro... but their development is prevented. Frozen eggs are usu... highly contaminated, for second grade eggs are used. An egg wh... is kept in cold storage is known as a chilled egg and must be ... tinguished from a frozen egg, which is tinned liquid egg froze... the tin, salt or sugar being added occasionally.

DRYING. The drying of eggs is the most suitable method of ... servation for transport purposes. The liquid eggs ... mixed with a little water and bicarbonate of soda to give a unif... mass and then rapidly dried. At present there are two comm... methods for the drying of eggs. In the first method, the liq... egg is spread in a thin film on a dried surface at a temperatur... 113° F. This temperature is sufficient to dry the thin film of ... without coagulation of the proteins. The dried egg is scraped ... and reduced to a rich yellow powder.

The second method is similar to that used in the prepara... of milk powder. (See page 240.) The liquid egg is pumped u... pressure through small openings in the form of a fine spray in... chamber kept at 113° F. The spray rapidly dries, and falls to... floor as a very fine powder. Sometimes the whites and yolks ... dried separately although the yolk on account of its fat con... does not readily powder. Dried eggs contain less than 7 per c... moisture, which is much too small for bacterial growth. Prov... dried egg powder is kept dry it will keep indefinitely. Dess... eggs are greatly contaminated with bacteria, doubtful eggs b... often used. The numbers of bacteria are generally higher in ... dried by means of a vacuum drum than in those dried by spra...

constitute the original egg before use for confectionery one part of the dried product is mixed with three parts of er for 24 hours. To make up the egg from separated white , 1 part of dried white is mixed with 7 parts of cold water rt of dried yolk is mixed with 2 parts of cold water. Equal each give a reconstituted egg.
is little or no loss in dried eggs of vitamins A, C, D but 30% itamin B_1.

Composition of Dried Eggs.

(Per cent.)

Water	Ash	Protein	Fat	Calories per lb.
6·6	3·9	40·3	39·6	2,598·1

stitutes. We have already seen that the use of eggs in baking and cooking is chiefly as aerators, and white of egg is the part which beats up into a froth and s air bubbles in its sticky glutinous substance, which are in the cake until it is baked. Many egg substitutes are tured which simulate the aerating power of white of egg. ubstitutes generally contain starch, bicarbonate of soda, acid, and some glutinous colloidal substance such as casein imed milk), albumin (from blood of slaughtered animals), n from bones. The mixture is given the appearance of egg addition to it of some colouring matter such as turmeric, carotene or other dye. It will be seen that the mixture is aking powder type, and when mixed with water the carbon evolved by interaction between the tartaric acid and nate of soda is retained by the colloidal substances and the beats up in a similar manner to egg. Such mixtures are to eggs as aerating and strengthening agents, and are in no parable with eggs as food materials.

Powders. Custard powders may be either similar in composition to egg substitutes as given above, merely consist of cornflour or other form of starch with g and flavouring material added. Here again there is empt at food value, and when mixed with a little cold milk ste and then stirred with boiling milk the mixture sets on owing to the formation of a thick starch paste.

EXPERIMENTS ON EGGS.

Experiment 1.

the shape of the egg and the porous character of the shell. e shell and carefully separate the white and the yolk into evaporating basins. Try to pick out the shell membrane, ber, fibrous white and germinal disc.

Experiment 2.

To determine the percentages of shell, white and yolk in an

Weigh an egg. Break the shell carefully and separate the w and yolk as completely as possible into two previously w evaporating basins. Weigh each basin with its contents an subtraction obtain the weights of the white and the yolk. F weigh the shell and work out the percentage of each.

Experiment 3.

To determine the chemical composition of shell, white and yolk

(a) Shell and shell membrane.

Break up the egg-shell without membrane into small pieces place in 10 per cent. hydrochloric acid for several days. Note immediate effect and the changes which take place after some t Evaporate the liquid and test the residue for calcium and p phorus (compare bones, Experiment page 271).

Determine for yourself the composition of shell membrane.

(b) Egg-white

Test egg-white for protein, fat and carbohydrate (starch and sug by the methods already given. Determine the percenta of moisture and ash. Identify the chief mineral constituents of t ash.

(c) Egg-yolk.

As with egg-white test for proteins, fats and carbohydra (starch and sugar). Determine the percentage of moisture and a Identify the chief mineral constituents of the ash.

Experiment 4.

To illustrate the use of egg-white as an aerating agent.

Examine some egg-white, noting particularly its sticky glutin character and alkaline reaction. Pour some of it into a test-t and equal volumes of water, soap solution and olive oil in ot test-tubes. Shake all the test-tubes equally well and leave stand. Note how long the froths produced remain intact.

Experiment 5.

To show that egg-white is a protein.

Experiments to show the effect of heat, temperature of coag tion, coagulation by alcohol and acids, colloidal character colour tests have already been described under proteins, p These experiments should be repeated.

Experiment 6.

To test the freshness of an egg.

e Test.

re a fresh egg, an egg several days old, a rotten egg and, if a partially incubated egg. Place in a 10 per cent. brine in a tall jar and note the positions taken up by the eggs. e fresh egg for several days and repeat the test. Explain.

ling Test.

andling lamp is available test the same eggs by this method. ively, devise some simple candling lamp using an electric Compare the results with these obtained by the previous Explain.

Experiment 7.

o examine an egg substitute and a custard powder.

ine a sample of egg substitute for protein, fat and carbo- (starch and sugar). Note whether aerating agents are If aerating agents are present try to determine their by the methods described under Baking Powder, page 203. ure of any artificial colouring matter can be determined by nods described under " Artificial Colouring Matters in Food " 7.

stinguish between genuine dried egg powder and " egg " mix a little of the sample with water and heat. " Egg " will effervesce (test for carbon dioxide) and the starch will gelatinise. Genuine dried egg powder will coagulate on heating but will not effervesce. The genuine egg powder mix readily with water.

t the same tests with a custard powder. In both cases, n their dietetic value as compared with that of actual eggs.

CHAPTER XIX.

COOKING.

Ovens. Cooking is effected in an oven by mean of radiant heat emitted from the hot walls the oven, of the general heat of the enclosed air the case of the fire-oven, using either coal, coke, wood oil as fuel, and in the case of the gas oven of radian heat emitted directly from flaming gas jets, or fro the resistance coils or elements in the case of some type of electrical ovens. Radiations emitted at high tempera tures pass in straight lines from their source to an obje without much absorption, the dry air raising its tempera ture but little. They are absorbed at the surfaces an within the substances of liquids and solids, which consequence become heated. In the case of oven-good heat liberated at their surfaces gradually passes inward by conduction and slowly raises the temperature, so tha the various cooking changes are effected within th substance, whether it is dough or meat. Not all of th liberated heat is absorbed by the food, for much is use in evaporating the water from its surface.

The air in the oven is warmed mainly by direct contac with the heat surfaces or heating elements, and in the cas of the gas oven by large admixture with the products combustion. In closed fuel ovens and electric ovens th air within, after the preliminary phase of heating up, but little disturbed by convection currents, other tha those arising in the course of the evaporation of moistu from the surfaces of the goods. In gas ovens, which necessity are open below to admit air wherewith to bu the gas, convection currents are stronger and continuo due to the strength of draughts, if much gas is burnt if the pull of the flue is considerable.

The several gases comprising coal gas, with the exce tion of nitrogen, require oxygen and consequently air f their combustion to form carbon dioxide and water vapou The volume of oxygen required for the combustion of

bic foot of coal gas (both measured at ordinary tempera-
e and pressure) is 0·9 cubic foot, corresponding to
cubic feet of air which must enter the oven from
hout. When 1 cubic foot of gas is burnt the total
ume of gases passing away from the region of combus-
n is 5·01 cubic feet as measured at ordinary tempera-
e, but actually much greater at the high temperatures
the heated gases. In the case of a gas oven burning
cubic feet of gas per hour, the volume of cool air
tering per hour is therefore about 110 cubic feet ; while
t of the hot flue gas escaping is more than double this.
a consequence there is a definite current of air and
ses passing through an ordinary gas oven. Another
ult is that a portion of the heat liberated by the
rning gas is consumed in warming the current of cool
, and a further portion is carried away in the escaping
e gases. If more cold air is drawn in that is actually
quired for the purpose of complete combustion there is a
rther reduction of the efficiency of the oven. The rate
which this excess air is drawn into the oven depends
on (1) the resistance of the air inlet and flue outlet,
) the rate of gas consumption, and (3), chiefly, the draught
eated by the hot light gases in the flue—the greater the
rtical height of the column of hot gases, the greater the
pull " upon the oven. Improvement in the efficiency
the gas oven depends mainly upon reduction of the
lume of products of combustion and of the strength of
e flue draught. This may be most readily made by
sulating the walls of the oven, so diminishing the loss of
eat by external radiation, and incidentally requiring a
naller supply of gas and the air necessary for its combus-
on, but sufficient to maintain the desired temperature of
e oven chamber. With a perfectly lagged gas oven the
ze of the gas flame need only be of the smallest to
tablish in due time cooking temperature or even beyond.

In the controversy on the relative merits of cooking by
s or by electricity it has been urged against the former
at the fumes of unburnt or incompletely burnt gases
ay have a deleterious effect on food when absorbed.
he usual defence against such an objection is that with

jets kept in order—a simple matter—the sole products of combustion should be carbon dioxide gas and water vapour, which could not possibly be absorbed by food while it was being cooked at the usual high temperature (400° F.) operating. Another argument against gas cooking is that joints lose more in weight by shrinkage and evaporation in gas ovens than in electric ovens. It would, however, appear from carefully controlled experiments, carried through by experts independent alike of the gas and electricity interests, that there is little or no difference in the matter of quality of cooking or of shrinkage-loss as between gas and electricity. Nevertheless there will always be differences of opinion, as of taste or fancy, on this point.

Gas versus Electricity. The controversy between the two modes of cooking—gas and electrical—really centres round matters of convenience and cost. The agreed advantages of electrical cooking are these:—the cooker, being independent of a flue and being also fed by a flexible cable, may be placed anywhere in a room or house reasonably convenient to a power plug and earth; its operation by switches is simple in the extreme; being lagged with non-conducting packing it scarcely affects the temperature of the room in which it is used; its appearance with light and coloured enamels is pleasing. On the other hand, gas cookers have at the moment certain advantages. In them cooking is faster than with electricity; quite a time—some twenty to thirty minutes—is required for pre-heating to bring an electric oven up to the high temperature (400° F.) for roasting. For boiling or simmering a gas ring is usually much quicker than an electric hot plate. Apparatus for regulating the temperature of the oven, rings and grills are much simpler and more finely adjustable in the gas oven than in the electric oven. In the matter of appearance by the extended use of chromium plating and coloured enamel the gas oven is challenging the electric oven. The use of lagging and the application of the results of research upon the details of air supply and of the placing of the exist of waste gases and heated currents, in the case of the gas oven, are

cing the serious drawbacks attending the heating of atmosphere of the kitchen.

n the score of costs, as between cooking by gas and electricity there has been the usual controversy, rally exaggerated by the claims of the two sets of smen.

may be premised that gas is now bought and sold at any pence per " therm " ; this being 100,000 British rmal Units (B.Th.U.), where the unit is the unt of heat required to raise one pound of water ahrenheit (B.Th.U. = 1 lb.°F.), and that electricity is ght and sold at so much per kilowatt-hour or Board rade Unit (B.O.T.), which is the energy available ng an hour's output of a kilowatt or 1,000 watts: vatt is a unit of power and equals the product of mpere of current and 1 volt of potential). For purposes omparison it should be noted that 1 kilowatt-hour B.O.T.) is equivalent to 3,412 British Thermal Units b°F.) or that 1 Therm is equivalent to 29·3 kilowatt-rs.

MPLES.

) A therm represents an amount of heat sufficient to heat 60 ns of water (600 lbs.) from 45·4° F. to boiling at 212° F.

(600 lbs. × 166·6°F. = 100,000 lbs.° F.)

) When town's gas gives 500 B.Th.U. per cubic foot of gas, a m is given by a gas ring consuming 20 cubic feet per hour, ing for 10 hours

(20 × 10 × 500 B.Th.U. = 100,000 B.Th.U.).

) The price of a therm varies with the undertaking and also the tariffs arranged for different classes of users. To a domestic umer in London the cost is 8·6d. per Therm and to one in an strial town on a coalfield it may be 6d. or even less.

as is measured by a meter in terms of cubic feet, and the readings converted into therms according to the calorific value of the Thus gas with a calorific value of 500 B.Th.U. per cubic and sold at 6d. per therm costs 2s. 6d. per 1,000 cubic feet ; n the calorific value is 480 B.Th.U. and the price per therm , gas costs 4s. per 1,000 cubic feet. The two modes of reckoning cost of the gas consumed are usually set out in the consumer's bill.

hus, 16,400 cubic feet of gas at 6d. per therm equivalent to 6d. per 1,000 cubic feet is charged £2 1s. 0d.

Electrical Quantities.

A Coulomb is a unit of electrical quantity (Q).

An Ampere is a unit of current (I) and is equal to one Coulomb per second.

$$I \text{ (amperes)} = \frac{Q \text{ (coulomb)}}{t \text{ (seconds)}} \text{ and } Q = It.$$

A Volt is a unit of electrical potential (E).

An Ohm is a unit of electrical resistance (R).

Ohm's Law states that $I \text{ (amps.)} = \frac{E \text{ (volts)}}{R \text{ (ohms)}}$.

A Joule is a unit of electrical energy or work (W) and 1 Joule = 1 Coulomb × Volt. (W = QE).

A Watt is a unit of electrical power and equals 1 Joule per sec

$$1 \text{ Watt} = 1 \text{ Ampere} \times 1 \text{ Volt.}$$

$$P = IE.$$

A Kilowatt is 1,000 watts.

A Kilowatt-hour is the B.O.T. unit of work or energy and equivalent to 3,412 B.Th.U.

The Kilowatt-hour (B.O.T. electrical unit) corresponds to the w done or heat evolved during an hour's passage of, say, 4 ampere current between points with a potential difference, due to resistan etc., of 250 volts. 1 Kilowatt is a unit of power and is equivalen 1·34 Horse Power.

EXAMPLES.

(*a*) An ordinary electric light bulb graded at 60 watts (60 ampe × volts)—on a current of 250 volts pressure takes a current of $\frac{60}{250}$ = ampere, and consumes $\frac{60}{1000}$ = 0·06 B.O.T. unit of energy in an h or alternatively runs for $\frac{1000}{60}$ = 16·6 hours for the price of a u

In an hour it transforms 60 watt hours of electric energy i

$$\frac{60 \text{ watt hours} \times 3{,}412 \text{ B.Th.U}}{1{,}000 \text{ watt hours}} = 204{\cdot}72 \text{ B.Th.Units of heat.}$$

(*b*) An electric fire on 200 volts service consumes 3 units per ho what current must the cable be arranged for, what is the resista of the element, and what is the heat output ?

i. 3 units per hour = 3,000 watts per hour.

(Volts × amperes = watts).

$$\therefore 200 \times I = 3{,}000.$$

$$\therefore I = 15 \text{ amperes.}$$

i. From Ohm's Law :—

$$R\ (\text{Ohms}) = \frac{E\ (\text{volts})}{I\ (\text{amperes})}$$

$$\therefore \text{Resistance} = \frac{200}{15} = 13{\cdot}3 \text{ ohms.}$$

ii. 1 B.O.T. Unit per hour is equivalentto 3,412 B.Th.U.

$$\therefore 3 \text{ Units} = 3 \times 3{,}412 \text{ B.Th.U.}$$
$$= 10{,}236 \text{ B.Th.U.}$$

An Electric Cooker on 220 volts service and taking 35 amperes

umes $\frac{220 \times 35}{1000}$ (Kilowatt hours) per hour = 7.7 units per hour,

at a cost depending upon the tariff.

n terms of cost, gas at 8·6d. per Therm, is equivalent lectricity costing 29·3d. at 1d. per unit ; that is gas in h a case as a producer of heat costs less than a third price of electricity, or more correctly 0·29.

n applying these facts to a comparison in the cooking ts between gas and electricity correction in favour of tricity must be made on the score of the loss of heat he case of the gas oven by way of flue gases and cooling general radiation from the oven itself. Comparison ts at the Good Housekeeping Institute in 1933 with ious types of modern gas and electric ovens have shown t to equal for ordinary domestic cooking purposes gas 8·6d. per therm electricity should be supplied at no re than about 0·5d. per B.O.T. Unit. Yet Dr. rgaret Fishenden in a paper read before the World wer Conference was of opinion that the cost of cooking s about the same with electricity at 1d. per unit and at 10d. per therm. In summary, where in large tres of population there is keen competition between gas and electrical supply industries for the service of sumers of heating energy, all parties being alert to provements in domestic appliances, there is at the ment little if any advantage on the score of cooking ts either way, unless perhaps it favours gas. But even extra cost may be largely offset by the saving due to greater cleanliness of cooking generally by electricity the much less deterioration of decoration of rooms house than when gas is used.

COOKING OF MEAT, ETC.

The practice of cooking meat and other flesh foods h grown up with civilisation and the general advance refinement of taste. Raw meat is, if anything, mo digestible than cooked meat, but to modern ideas it is n so presentable or palatable. Heat treatment of me results in the removal of its raw appearance by t decomposition of hæmoglobin, the partial coagulation the proteins of the meat fibres, the gelatinisation of t connective tissue surrounding the muscle fibres, and t loosening of these so that they become more accessib in digestion to digestive juices, and the melting away fats from amongst the masses of muscle. Pork is usuall difficult of digestion because in its case there is a supe abundance of fat, and this intimately associated with th muscle fibres so that the access to these of digestive juice is hindered. The starches and celluloses of vegetable when heated in water to about 170°F. are gelatinise and so made readily soluble in the processes of digestion

Cooking is mainly practised because it results in foo which is more appetising than raw foods to the taste, smel and eye. The scent of roast beef or of the morning rashe exercises on most persons definite psychological effects i starting up a series of conditioned reflexes, such as th secretion of the salivary and gastric glands, before food i either seen or eaten. With the sick or convalescen these aspects of preparation and presentation of food ar particularly important. For those in good health cooking has made of a primitive animal necessity an its satisfaction an art, if not also a science and a ceremony

The heating of food in cooking is sometimes justifie by the argument that parasites and pathogenic bacteri possibly contained in the raw food are wholly, o to a very large extent, killed by heat. With respect t this suggestion it need only be said that food known t contain such organisms should not be eaten under an circumstances. Unless meat inspection is thorough an the retailers well instructed in such matters and hones it is nevertheless true that diseased meat may pass int consumption. In such cases it must not be forgotten tha

temperatures reached in the ordinary process of king are quite insufficient to sterilise the meat through- all the more where the bacteria are in the spore form parasites are encysted.

he following processes of cooking are usually dis- uished :—

(1) Boiling.
(2) Steaming.
(3) Stewing.
(4) Roasting (Baking).
(5) Frying.

BOILING AND STEAMING are processes that have much common. The temperature of the medium in which meat is cooked, whether steam or water, does not above boiling point (212° F.) at ordinary pressure ; higher temperatures accompany increased pressure, n modern pressure cookers. The application of heat meat in either of these processes, as in others, results in coagulation of the proteins of the surface layers and, owing a very gradual penetration by conduction of t inwards, in the coagulation of the proteins within. at is a very poor conductor of heat, and convection of t by its juices would seem to be negligible in extent ; nay therefore take several hours for the centre of a en pound round of beef placed in boiling water to ch the temperature, even, of 190° F.

When meat is heated above 140° F. (60° C.) there is ays a loss in weight due largely to the escape of juices n the meat, and this is accompanied by a marked nkage. This shrinkage is due in part to the escape water and its contained salts from the coagulated scle cells, and in part to the shortening of the muscle es which takes place at 104° F. (40 °C.) and to their gulation at 145° F. (63° C.).

During steaming, juices exude from the piece of meat there is no evaporation on the surface with concentra- n of salts. The cooked meat does not become water- ged. Beef after steaming for three quarters of an ur may lose some 42 per cent. of its weight, and ox

kidney 54 per cent. Eggs when steamed actually gain little, for their proteins do not shrink when coagulated heated. If heating in steam is carried out at abo 177° F. (80° C.), that is under reduced pressure, the loss weight at first is less than at 212° F. (100° C.) but aft several hours reaches the same value: when heated 288° F. (120° C.), that is under pressure, the loss of weig at all stages is greater than at 212° F. At all temperatur the loss of weight largely takes place in the first hour cooking. When boiled at 212° F., beef loses practicall the same weight as when steamed. Fish, being mo liable to waterlogging, loses appreciably less than be either when steamed or boiled, and much less so in th latter instance.

When meat is placed in water there is always a tendenc for the salts dissolved in the cell sap to dissolve outward This process of leaching goes on almost as well in cold in hot water. When meat is plunged into cold water the beginning of warming it loses salts by leach alon until the temperature of the water reaches 140° F. whe shrinkage due to coagulation begins. In such circum stances the loss of soluble salts without any loss of th water in which they are dissolved may amount to 22 pe cent. of the total. Above 140° F. there is a further los of salts and of water due to contraction of the meat. I the case of eggs, however, there is no exudation of wate or its salts.

Cooking of meat by boiling does not require that th water should be actually at boiling point; a temperatur well below this, say 170° F., will be actually better, fo then there is little risk of the over-coagulation or hardenin of the muscle fibres.

In STEWING, meat is kept for a long period eithe simmering, or immersed in hot water, or enclosed in a oven at boiling point; evaporation is then reduced to minimum, and the meat is cooked in its own juices. variant is "hay-box" cooking, in which a piece of meat first heated in a vessel with a fair quantity of water whic is finally brought to the boil, and then the whole is place in a non-conducting enclosure and kept there for man

rs (say, 12 to 18), during which time heat slowly trates the meat. In the course of this long and slow ing at temperatures lower than the boiling point the eins are partially hydrolysed and semi-digested, so even tough but cheap cuts of meat may thus be made er and well flavoured. Much more use could be made ow cooking of this type in the home kitchen as well as ravel or in camping out. Where time is not a primary ideration the method has every advantage.

Roasting, meat is subjected to radiant heat, either the old practice when turned on a spit or on a jack ront of a hot fire, or as in modern practice beneath the of a gas cooker or in a dutch oven before a fire or e generally in an enclosed oven heated by coal fire, or electricity.

his method in any of its variants is usually preferred ny of the others because it results, not only in more oury and appetising food but also in there being less nkage by loss of water, and in the fact that the loss eight and bulk is to some extent compensated for by retention of the drip of exuded juices as gravy. The ller loss of water, and particularly of salts, in the case ordinary roasting has been generally ascribed to the nation of a protective coating, or pellicle, by the gulation of the proteins of the surface, which prevents egress of water and salts. Recent researches, how-r, go to show that the pellicle as usually formed on the face is far from complete, and even if complete that it ld not account for the marked diminution in the of salts. The smaller loss of water in ordinary sted meat is more probably due to its not being so pletely cooked as boiled meat. In roasting, the centre joint never reaches 212° F., and for well done meat best temperature is 180—185° F. Evaporation at surface in the dry and hot atmosphere usual in roasting nost probably the cause of the comparatively small of salts, in that a fair proportion of the exuded juices left on the coagulated and dehydrated proteins and er materials formed on the surface. During a long iod of experimental roasting the loss of water is

continuous, and in the case of small pieces may rise
70—80 per cent.—a behaviour in marked contrast wi
that of boiled or steamed meat where the loss is alwa
rapid at first, and then ceases sharply on the completi
of shrinking. The salt losses are at first relatively ve
small and even at the end are much below those usual
boiled or steamed meat—in one set of experiments 10 p
cent. only as against 50 per cent. These features of roa
ing may be explained in terms of evaporation at t
surface and shrinkage of protein whenever the coagulati
temperature has been exceeded. When meat is exposed
dry air to a high temperature of radiant heat evaporati
at once begins, as is indicated by loss of water and weigh
As the heat slowly penetrates the interior the protei
shrink and force the juices out upon the surface which ha
already lost much water. Some of the water in this jui
is immediately evaporated, while the remainder runs dow
the surface of the meat losing water by evaporation a
the time until the salts crystallise on the outside. Th
salts lost to the meat are in the drip. When the meat
finally shrunk no further juices are expressed from th
interior and the loss of salt is stopped, although wate
may continue to be lost by surface evaporation.

Meat may be roasted in an oven in either of two ways
in the open or in a closed tin, the difference being almos
entirely one of the rate of evaporation. It has been foun
that in the covered roast where evaporation is muc
diminished there is a much greater loss of salts from th
meat than in the open roast, and that owing to the larg
reduction of evaporation, which requires latent heat o
evaporation, the closed meat cooks more quickly than th
uncovered meat. An enclosed roast loses more weigh
and water than the open roast as a result of its more rapi
cooking and earlier shrinkage.

Frying is the process of cooking meat or fish in hot fat
which can attain much higher temperatures than ar
possible with water. In shallow fat evaporation is give
free play, and in deep fat it is considerable for there th
flesh is immersed in a hot liquid immiscible with wate
While the losses in weight and of water tend to be hig

ing to the temperatures reached the losses of salts and proteins are considerably reduced. In frying small ces of flesh, such as steaks or fillets, heat quickly netrates to the centre, so that the meat is quickly cooked may even be overcooked and made less digestible. But the whole where reasonable care is exercised frying is a y conservative and appetising method of cooking aller joints or cuts, and is definitely so in the case of ets of fish.

The essential character of frying is its rapidity at usually high temperatures. In practice this, however, often moderated by enclosing the food with a coating a badly conducting substance, such as bread crumbs mented by white of egg, batter or pastry, into which the oking fat also penetrates but not far into the meat elf.

Various fats of different melting points and boiling or composition points are used for different purposes: z., butter with low melting and "boiling" points for ed eggs: lard, for egg-mixtures; mixed dripping from con and joints for frying already cooked meats; ndered fat from beef or mutton suet for fillets of fish, eak or chops. Cotton seed oil, with a high boiling point 50—390° F.) is generally used in commercial fish-frying.

CHAPTER XX.

CANE SUGAR.

The history of the sugar cane as a source of sugar in India (Bengal), China, Egypt and Greece goes back to ancient times. The Arabs carried its cultivation from the East along the southern shores of the Mediterranean into Spain and Portugal, from which countries it was carried to the New World on its discovery, and there developed early in Brazil and the West Indies. At the present time it is cultivated in all continents, but chiefly in Asia and America. The world output in 1936/37 was just over 19 million metric tons.

Cane sugar was first extracted commercially from beet early in the nineteenth century during the Napoleonic wars, when continental Europe was largely cut off from its usual supplies from the two Indies. But it was not until after 1828, in France and 1836 in Germany that its manufacture was a commercial success. In 1866 beet sugar was 30 per cent. of the total world sugar product of 3,000,000 tons; in 1887 it was 47 per cent. of 5,000,000 tons, in 1910 it was 46·5 per cent. of 15,000,000 tons and in 1930/31 it was 39·4 per cent. of 29,240,000 tons. The world output of beet sugar in 1936/37 was 10,210,323 metric tons, i.e., 35 per cent. of the total sugar.

The Anglo-Saxon nations, chiefly Britain and the U.S.A., are by far the greatest consumers of sugar. The consumption in Britain is 2 million tons, which corresponds to the rate of 100 lbs. per head per annum. The straits to which the general population of Britain was reduced during the latter years of the First World War in the matter of sugar supplies, among other reasons, were such as to stimulate the development within our own country of a sugar beet industry. This ultimately produced annually 620,000 tons instead of the 3,000 tons in 1914, but at considerable cost to the Exchequer, having received during the 10 years 1924/33 £30,000,000 subsidy and a further £10,000,000 in duty remission.

Manufacture of Sugar.

he manufacture of sugar from either sugar cane or beet root s into three main stages: (i) extraction of juice; (ii) concen- ion of the juice and crystallisation; and (iii) refining of the ar.

Extraction.

he crushed sugar canes or beets when pressed yield a juice contain- in the case of sugar canes 15-19 per cent. sugar and in the case beet 20-25 per cent. A more improved method, that of usion, depends on osmotic interchange between water at 70° C. and sugary saps of the cells of sliced beets or crushed canes, as a lt of which only 0·4 per cent. sugar is left in the beets and er cent. in the canes. The raw juice thus obtained is a weaker ution than the pressed juice and costs more to concentrate. e exhausted cane or beet is used as cattle food.

Concentration, Evaporation and Crystallisation.

he raw juice contains in addition to sugar, various other plant oducts such as pectins, proteins and mineral salts. These are utralised or coagulated by being heated at 86–90° C. with a 1 per t. suspension of milk of lime. In order to prevent an excess of e, which would throw down some sugar as calcium sucrate, rbon dioxide gas is passed into the solution so that calcium rbonate is precipitated. This is separated two or three times at igh temperature. Finally the purified solution is filtered. The ce now contains 10–11 per cent. of sugar, and is progressively ncentrated by being evaporated with steam coils under several ages of reduced pressure and corresponding temperatures; the essures range from 640 mm. of mercury for the fresh juice to 150 n. for the most concentrated, and the temperatures from 56°C. to ° C.

When fully concentrated the dark brown liquor contains 50-55 r cent. sugar. It is filtered and further evaporated to a concentra- n of some 85 per cent. when crystallisation begins around the eam coils, and is allowed to complete in cooling tanks with stirrers. e crystals are separated as "first product sugar" from the olasses, or mother liquor, in centrifugal machines. The molasses further evaporated and allowed to crystallise to give a "second oduct sugar," leaving a second molasses, from which more crystal gar may be obtained if required. Molasses from beet juice may ntain 40 to 50 per cent. sucrose, and a little (1·5 per cent.) invert gar as a result of the action of acid. Sugar does not however ystallise from this molasses owing to the presence of 8–10 per nt. mineral salts, notably of calcium.

Refining.

Raw sugar consists of the first and second product sugars, and quires to be decolourised usually by animal charcoal, occasionally

by sodium thiosulphate, and purified by solution and recrystallisation. The crystals are separated as granulated sugar from the mixture of syrup and crystals, the massecuite, by a current of hot air.

Various Grades of Sugar. By repeated crystallisation and re-evaporation of the molasses in vacuum pans three or four grades of sugar are obtained. The first crystallisation yields the highest quality known as "firsts"; "seconds" are slightly inferior to firsts, while thirds and fourths are generally put on the market as partially refined or raw sugars. The firsts and seconds are obtainable in all the various forms of sugar, such as loaf sugar, lump or cube sugar, splits, nibs, granulated sugar, crystal sugar, caster sugar and icing sugar. LOAF SUGAR is prepared by allowing the crystals to set in a conical mould. When the superfluous molasses has been drained off a conical mass of loaf sugar is left.

CUBE OR LUMP SUGAR is prepared by passing the product from the vacuum pans into special centrifugal machines in which the fine grained crystals cake into a hard mass. This cake is removed, dried off by gentle heat and then cut into cubes by machinery and sieved. Broken cubes which pass through the sieves are graded by finer sifting into SPLITS and NIBS.

GRANULATED SUGAR is prepared from small grain crystals in long double iron cylinders known as granulators. These are heated and revolved to form granulated sugar.

CRYSTAL SUGAR is prepared in a similar manner to granulated sugar, except that fresh liquor is used in place of the old so that a fresh batch of sugar crystallises out and settles on those already present with the resultant formation of much larger grains. YELLOW CRYSTALS are formed by the addition of 2 per cent. golden syrup to crystal sugar, and contain a little yellow colouring matter.

CASTER AND ICING SUGARS.—These milled sugars are prepared by placing rough sugar crystals in fixed drums fitted with mechanical beaters which revolve at a great speed and break up the crystals into very small particles.

ese particles are graded by sieves into the three sizes caster sugar. The powder goes through silk sieves and ms icing sugar.

GROCERY PIECES, SOFT PIECES OR SOFT SUGAR.—In preparation of this type of sugar the crystallisation rranged to give a larger number of crystals of smaller in than in the previous cases. It is brown and low, or in the case of West Indian sugars, white. It is w grade sugar.

COLOURED SUGARS are simply sugars of one or other the above types coloured by the addition of some mless coloured fluids.

DEMARARA SUGAR AND MUSCOVADO SUGAR are sugars ich are put on the market straight from the plantation hout being refined.

GOLDEN SYRUP is a mixture of cane sugar, invert sugar l water, made by partial inversion of cane sugar by ting with cream of tartar.

Composition of Golden Syrup.

	per cent.
Sucrose	33·5
Glucose	24·5
Lævulose	23·0
Salts, etc.	2·5
Water	16·5
	100·0

Calorific value 1,510 *Calories per pound.*

MOLASSES OR TREACLE is the syrup or mother liquor n out from muscavodo sugar. It is rich in invert gar (20 to 37 per cent.) and has a calorific value of 44 to the pound.

t is impossible to distinguish whether a " firsts " sugar derived from sugar cane or sugar beet, but with lower des cane sugar is preferable. Refined white sugar is

chemically one of the purest of foodstuffs, containing a it does over 99·9 per cent. sucrose. Sugar whether ra or refined is devoid of any vitamins. Its calorific valu is 1,860 Calories per pound, and it is the cheapest and mo readily available source of energy among foods

Sugar Derivatives and their Preparation.

Sugar Candy.—This is prepared by suspending thi strings in a hot concentrated cane sugar solution. Th sugar slowly crystallises out on the string in the form o large cubic crystals.

Barley Sugar.—When cane sugar is heated it melts a 100°C. If a little water is previously added to the suga it melts at a slightly lower temperature. The melte sugar becomes straw-coloured and on cooling sets to a brittle non-crystalline mass of barley sugar. Whe prepared by confectioners it is either cast into moulds o twisted into strips before it hardens.

Caramel or Black Jack.—On further heating suga darkens in colour and at about 210° C. is converted into a dark brown substance known as caramel. This has th smell and taste of burnt sugar, and is much used as a colouring and flavouring material in sauces, gravy brown ing, "artificial" vinegar, rich cakes, soups, spirits liqueurs, beers and stouts.

Fondants.—Fondants are really of two types—thos used by sugar boilers as sweets, and those used by con fectioners for cake decoration. The principles underlyin their preparation are, however, in both cases the same and consist in the formation of a sugar syrup which doe not crystallise out on cooling. In other words it sets t a permanent solid mass instead of becoming "crumbly" or "sugary." This "cutting of the grain," as it i called, is accomplished by partial "inversion" of the can sugar, or the addition to it of a certain amount of glucose The presence of even small amounts of glucose in a suga syrup prevents the crystallisation of the sugar on coolin or keeping. Actually, crystallisation does take plac slowly but the crystals formed are so small as not to caus disintegration of the solid mass. It is for this reason tha

fondant and toffee recipes will be found to contain her glucose or small amounts of such acid substances cream of tartar, tartaric acid, citric acid, lemon juice, etic acid or vinegar. During the boiling of the sugar rup the acid substance present inverts part of the cane gar to form sufficient glucose to prevent crystallisation.

TOFFEES AND SWEETS.—We have already seen that nen sugar is heated it first of all melts and on continued ating turns dark brown to caramel. On still further ating it turns black to form sugar charcoal or carbon, d finally burns completely away. In actual fact there a large number of gradual changes in the sugar between elting and caramelisation which are not easy to distinish except by the experienced eye. An experienced gar-boiler can recognise eleven different and distinct ages or " degrees " as follows :—

Syrup	... 215°–220°F.
" Thread " degree ...	... 225°F.
" Pearl " degree	... 230°F.
" Blow " degree	... 235°F.
" Feather " degree ...	... 240°F.
" Soft ball " degree ...	... 245°F.
" Hard ball " degree ...	... 250°F.
" Soft crack " degree ...	... 280°F.
" Hard crack " degree ...	... 300°F.
Caramel	... 350°F.

These various " degrees " can be determined best by the use of a gar boiler's thermometer on which the various temperatures are arked, or in skilled hands by the shape and consistency of a sample oured into cold water. For ordinary purposes only four of these egrees are of any real importance. They are " thread " degree r boiled icing, " soft ball " degree for fondants, " crack " degree r toffee, and " caramel " for colouring and flavouring. These rrespond with temperatures of roughly 225°F., 245°F., 290°F. d 350°F. respectively, or can be less accurately determined by the llowing simple tests.

THREAD DEGREE.—A spoon is dipped into the syrup, or a finger pped first into cold water and then into the syrup and, immediately ck again into cold water. If a thread is formed when the syrup squeezed between finger and thumb and they are separated the thread " degree is reached.

SOFT BALL DEGREE.—A sample is poured into cold water from a oon and when worked between the finger and thumb forms a soft all.

Crack Degree.—At this degree a sample poured into cold wat will crack and when taken out will be found to be hard, dry a brittle.

Caramel. The sugar begins to darken rapidly in colour and t smell of burnt sugar becomes noticeable.

Other points of importance in sugar boiling are that the sides the pan should be kept free from particles of sugar, and that the sugar has begun to boil and the scum removed the sugar sh be brought quickly to the required degree without stirring. T presence of sugar particles on the sides of the pan or stirring durin boiling is liable to cause graining, i.e., the batch will become crumb on setting.

Honey. Honey is deposited by bees in the cells of wa combs, and is derived in the first instance b them from the nectar of the flowers they visit. While i the body of the insect the nectar sugar undergoes change chiefly inversion, so that honey sugar is almost entirely invert sugar, making 75 per cent. of the total mass. Th flavour and aroma are due to the scents derived from th flowers; honey of different origins may thereby be dis tinguished, e.g., heather honey and clover honey. A ready means of distinguishing real honey from artificia honey is by use of the microscope, when abundant and distinctive pollen grains are evident in the case of the former.

During ancient and mediaeval times honey was th chief source of domestic sweetening materials. There are occasional references to bee-gardens in the Domesday Book When allowed to ferment, a solution of honey or washings from combs produces mead, a popular drink among the Anglo-Saxons and the Vikings, and still available in country districts of Hampshire and Sussex.

EXPERIMENTS ON CANE SUGAR.

Experiment 1.

To show the inversion of cane sugar.

Prepare a 10 per cent. solution of cane sugar and test a sampl of it with Fehling's solution. No precipitate of cuprous oxide wi be formed on warming. Now add a few drops of concentrate sulphuric acid or hydrochloric acid and boil for some time. Neutralis the solution by the addition of caustic soda solution and then te it with Fehling's solution. A reddish brown precipitate will now b formed showing the presence of a reducing sugar. The disaccharid

se, has been hydrolysed into a mixture of two monosaccharides, ose (glucose), and lævulose (fructose). The process is known version and the mixture of the two sugars produced as "invert" .

peat the experiment using tartaric acid or citric acid in place e mineral acids previously employed. It will be found that ugh longer heating is necessary the same result is achieved.

te the significance of these experiments in connection with the ng of fruit, the preparation of jam, etc.

Experiment 2.

To prepare a sample of sugar candy.

epare a concentrated sugar solution in a beaker of water. o get as much sugar as possible dissolved without raising the erature unduly. Suspend in the thick syrupy solution a length read tied to a glass rod across the top of the beaker. Set the er on one side for several days and note the formation on the g of large cubic crystals.

Experiment 3.

To prepare a sample of barley sugar.

a quantity of cane sugar in a large evaporating basin add a water and heat gently. Stir until all the sugar is melted. inue the heating until the syrup becomes pale-straw coloured. to cool. A hard solid mass of barley sugar should be obtained. k off a piece of the solid and taste it.

ntinue to heat the remainder gently until it boils. Note any ge that takes place in the appearance of the boiling syrup. ort intervals pour small samples into cold water. Take the les out and examine them. Try to recognise to which "degree" belong. If a sugar boiler's thermometer is available this d be used for purposes of comparison. (See page 301.)

Experiment 4.

To prepare a sample of caramel.

ntinue the heating of the sugar in the previous experiment it darkens in colour and gives off a smell of burnt sugar. to cool at this stage. When cold, taste a little of the sample aramel. Dissolve a little in water, note the colour of the solution est it with litmus paper and also with Fehling's solution.

ntinue the heating of the sugar in the basin until it turns to charcoal, ignites and finally burns completely away.

Experiment 5.

To illustrate the process of "cutting the grain."

Warm together 30 gms. of cane sugar and 10 ccs. of water un clear solution is obtained. Divide the solution into two eq portions. To the first portion add a pinch of tartaric acid. W the solutions on water baths for the same length of time. A heating, leave both solutions to stand. Note that the cane su solution begins to crystallise out and if left long enough bec solid. The solution to which tartaric acid was added rema liquid.

Experiment 6.

To illustrate the preparation of various sugar products.

(*a*) Heat 100 gms. of white granulated sugar with 50 ccs. of wa in an enamelled saucepan. Stir until the sugar has complet dissolved. At 240° F. add 0·2 gm. of tartaric acid to "cut t grain" and continue the heating to 300° F. ("hard crack" degr Pour the syrup slowly on to a previously greased slab or shall tin. Allow the sugar to cool and while still plastic cut off in strips with a sharp knife and twist the strips between the fin and thumb. In the light of this experiment examine recipes the preparation of *barley sugar, acid drops, fruit drops* and *toffees*.

(*b*) Heat 100 gms. of white granulated sugar with 40 ccs. of wa and 0·1 gm. of cream of tartar to 240° F. ("feather" degre Pour the syrup into a glazed earthenware basin and allow stand until it cools to 100° F. Now stir the syrup with a wood spoon from the side of the basin towards the centre. Not that the sugar becomes more and more viscous and creamy appearance. When it becomes too stiff to be stirred knead it wi the hands into a smooth creamy mass. This is *fondant* which h been formed by partial crystallisation of the sugar due to t stirring and kneading. It is used in sweetmeats and for coati cakes. Alternatively the plastic mass of hot boiled sugar can pulled over a hook into a long rope and folded and refolded up itself. The folding and refolding has the same effect of part crystallisation that the stirring and kneading had. The sug becomes fibrous and shiny and on keeping rapidly hardens in "*rock*."

EXPERIMENTS ON HONEY.

Experiment 1.

Estimation of reducing sugar present.

This can be determined volumetrically using Fehling's soluti by the method described on page 58. The percentage of reduci sugar should be between 70 and 80 per cent. A higher figure sugge adulteration with glucose syrup or artificial honey (invert sugar)

Experiment 2.

Estimation of cane sugar (sucrose) present.

50 ccs. of a 1 per cent. solution of the sample of honey add . of concentrated hydrochloric acid. Heat on a water-bath for n minutes to invert the sucrose present. Cool and then add sodium carbonate until the solution is alkaline. Make the me up to 100 ccs. in a graduated flask.

termine the percentage of reducing sugars as before using ng's solution. This result will be greater than in the previous rument owing to the presence of inverted cane sugar, and its nt can be determined by subtracting the amount of reducing r before inversion.

nuine honey might contain up to 8 per cent. sucrose. A er percentage is an indication of adulteration with cane sugar.

Experiment 3.

Estimation of ash.

etermine the percentage of ash by the method described on page The percentage should not be greater than 0·25. A higher entage suggests the presence of glucose syrup which is liable to ain calcium sulphate. (Why ?) A lower percentage suggests presence of artificial invert sugar.

Experiment 4.

To test for the presence of glucose syrup.

issolve the ash obtained in the previous experiment in dilute rochloric acid. To a portion of the solution add barium chloride tion. A white precipitate of barium sulphate is an indication he presence of sulphate.

o another portion of the solution of ash add ammonia and monium oxalate solution. A white precipitate of calcium ate, insoluble in acetic acid and soluble in hydrochloric acid, is ndication of the presence of calcium.

glucose syrup has been added as an adulterant to the honey, nic as well as calcium sulphate may be present in small amounts y ?) It may conveniently be tested for by Reinsch's test as ows :—

issolve about 5 gms. of the honey in dilute hydrochloric acid. e a small piece of clean bright copper foil in the solution and heat oiling. Any arsenic present will be deposited on the foil as a film. As a further test, remove the foil and carefully wash dry it. Place it in a glass tube and heat cautiously. Arsenic give a crystalline sublimate of white arsenic (As_4O_6) on the er parts of the tube. With ammonium sulphide the sublimate form yellow arsenic sulphide (As_2S_3).

Experiment 5.

To test for the presence of artificial honey (invert sugar).

(*a*) **Browne's test.**

The reagent used in this test consists of a freshly prepared solut of aniline acetate made by shaking together 5 ccs. of aniline a 5 ccs. of water and sufficient glacial acid to give a clear solution.

Shake together 5 ccs. of the honey and 5 ccs. of water in a tes tube. Hold the test-tube in a sloping position and carefully po down the side a few ccs. of the aniline acetate solution so as to for a separate layer on the surface. If invert sugar is present a red ri forms below the aniline acetate layer and, on gently shakin gradually spreads throughout the whole solution.

(*b*) **Fiehe's test.**

Shake thoroughly together in a test-tube 5 ccs. of the hone and 5 ccs. of water. Add 5 ccs. of ether and again shake thoroughl Place the mixture in a stoppered separating funnel and leave t stand. Separate the ether layer and add to it a few drops of 1 per cent. solution of resorcinol in hydrochloric acid. Shak gently. In the presence of invert sugar a red colour will be develope

Experiment 6.

To test for the presence of dextrin.

(*a*) Dilute some of the honey with an equal volume of water in test-tube. Shake well and then add a little iodine solution. reddish brown colour indicates dextrin.

(*b*) To a mixture of equal parts of honey and water, add alcoho slowly and stir well. The formation of a white precipitate indicate dextrin. (Why might dextrin be present in honey ?)

Experiment 7.

To examine a sample of golden syrup.

Identical tests can be carried out with golden syrup as already described for honey.

The percentage of reducing sugars should be between 40-45 pe cent. Higher percentages indicate adulteration with cane sugar The percentage of ash should be about 0·75 per cent. If the per centage is above this, test the ash for calcium and sulphate. (Why ?

CHAPTER XXI.

FRUITS AND VEGETABLES.

Fruits.

TANICALLY considered, a fruit is the modified pistil
a flower or more strictly the ovary and its contents,
ovules, as developed after the fertilisation of the egg
s by pollen. The pistil consists in all of (i) the stigma
which the pollen grains alight; (ii) the style down
ch the pollen tubes grow; and (iii) the ovary, an
losure in many instances partitioned, in which are
tained one or more ovules. After fertilisation the
le develops as a seed, its integuments becoming the
d coat, or testa, within which is contained the embryo,
er filling the whole of the space, or being enclosed
further in food stores or endosperm. Meanwhile the
ry containing the seeds increases considerably in size,
is often much modified in structure, its wall becoming
pericarp.

Fruits are conveniently divided into two main classes
ording to the character of the pericarp; namely,
dry fruits and (ii) succulent fruits. In the former
s the pericarp is on the whole dry and tough, and not
h as would normally be eaten, either as a fruit or
etable; examples are the husks of hazel nuts and the
scods of peas. In succulent fruits the pericarp is in
t, and often considerably so, pulpy, and when it
tains sugar and substances of flavour and aroma, may
both attractive and edible; this would appear to be
ir significance in nature, attracting animals so that they
ght disperse the seeds. Succulent fruits are usually
ther divided into two main groups: (i) the stone
ts (drupes); and (ii) the berries (baccas). In stone
ts the pericarp is formed of three distinct layers or
nes: (i) the outer skin, rind or "epicarp"; (ii) the

pulp or " mesocarp " often edible : and (iii) the stone
" endocarp " within which is the kernel or seed containi
the embryo. In the case of berries the innermost lay
of the pericarp is not stony or in any way toughene
and is usually scarcely different from the pulpy mesocarp
the epicarp is the skin or peel. Among berry fruits a
gooseberry, grape (including raisin and currant), blac
and red currants, the citrus fruits (orange, lemon, lim
grape fruit), banana, tomato, cucumber, marrow an
melon.

Common examples of stone fruits are apricot, peac
plum, sloe and cherry. The almond, coconut and walnu
are also examples of stone fruits ; but as usually marketed
the two outer layers—skin and pulp—have been stripped
and only the endocarp or stone left with the kern
inside.

Besides the drupes and berries, there are other type
of succulent fruits, which are distinguished botanicall
from these in some important respect or other. Th
blackberry, dewberry, raspberry and loganberry ar
aggregate fruits consisting of several small drupes an
not, as their names would suggest, berries. The mulberr
is a compound fruit formed by the fusion of the frui
forms of several originally separate flowers. The apple
pear and medlar are botanically false-fruits or pseudo
carps, because in their cases the greater part of the pul
is formed from the hollow receptacle of the flowers ; th
core with the pips being the representative of the origina
ovary. The pulp of the strawberry is formed by th
much enlarged and fleshy receptacle on which are carrie
scattered dry achenes. The pineapple is another pseudo
carp ; in its case the whole inflorescence stalk bearin
many flowers becomes more or less succulent. The fi
is formed from a deeply hollowed inflorescence axis, withi
which are scattered a large number of separate sma
flowers.

In many fruits, especially if freshly plucked, may b
made out the more or less withered remnants of th

floral parts, the stalk, sepals, petals and stamens, n some cases also the style or its scar at the pole of fruit. In cleaning small fruits for domestic use or anning or jamming it is these fragments that are ved by riddling and sieving, along with fragments of etc.

in. During the forming of a succulent fruit the ovary walls, as we have seen, become consider- enlarged by the rapid development of new tissue, succulent by the absorption of water. Food reserve erial is passed into the developing fruit from the plant, as cellulose of various kinds, among which mother substance of pectin, pectinogen, is in some s a considerable portion, and also starches and acids. ing ripening many changes take place, largely it would ar because of the activity of various enzymes secreted the cell protoplasm. The pecto-celluloses, containing inogen, are decomposed by the appropriate enzymes pectin and cellulose which may be also liberated unripe fruits by boiling with water containing either eral or fruit acids. Pectin dissolves readily in water colloidal solution, which coagulates as a jelly with ar and acid. Only those fruits which yield much tin when boiled to form jam set well; among these apple, gooseberry and vegetable marrow. Other ts require to be mixed with pectin-rich fruits, as wberry with gooseberry or many different fruits with etable marrow, or with prepared pectin, for their to set (see page 332). The celluloses and starches, their part are hydrolysed by their specific enzymes give sugars, chiefly glucose and to a less extent tose also. The tartaric, malic, citric and succinic ls which make unripe fruit particularly sour are either ely converted when the fruit is fully ripe into other stances, including sugars, or their taste is masked by excess of sugar. The particular flavour of a fruit is to small quantities of esters—compounds of alcohols h acids—and essential oils, distributed throughout the p, and in some cases, as in the citrus fruits, are particu- y abundant in the rind. Fruit is usually in its

most edible condition when the proportions of sugar a acid are so balanced as to be most agreeable to the pala When fruit is over-ripe some of the sugar and acid a oxidised and the essential oils and esters are destroy with a consequent loss of aroma and flavour. At t same time the fruit becomes less firmly attached to t plant and presently falls to the ground or bursts a ejects the seeds.

Food Value of Fruit. In most fresh pulpy fruits proteins a carbohydrates form a comparatively sma part of their mass, which is usually ma up largely of water and of seeds that are rejected in eatin Apart from the dissolved sugars and pectins their val as food stuffs lies mainly in their minerals and vitamin It is as protective foods and incidentally as providing certain amount of suitable roughage rather than as fle building or energy foods that dessert fruits are to most valued, and their proper role in a balanced dieta ascribed. The minerals of fruits, both as free organ acids or as their salts of potash, calcium, and iron, whe finally oxidised yield either no ash at all or one that alkaline, and consequently in the course of metabolis within the system serve not only to neutralise the acidit due to oxidation of proteins and carbohydrates, but als to maintain the alkalinity of the blood at its normal valu (see page 121). Some fruits, like the apple, banana an tomato, contain most of the vitamins, but it is the ant scorbutic vitamin C that is commonest in fresh fruit particularly the citrus fruits, and for which their consump tion is to be most commended. Yet as will be gathere from the table, the distribution of vitamins amon common fruits varies considerably. While oranges an lemons are particularly rich in C, limes are comparativel deficient. Tomatoes are more varied than most fruits i their vitamins. In respect of C, tomatoes ripened whi on the plant or after plucking are rich, but when gree are lacking. Tinned tomatoes, especially when made b the most modern methods, are but little less rich in than when fresh. Grapes as sources of vitamins a useless. Fruits are all lacking in D.

rage Composition of Some Common Fruits (as bought).
(per cent.)

	Refuse	Water	Ash	Protein	Fat	Carbo-Hyd.	Calors. per lb.
...	25·0	85·3	0·3	0·3	0·3	9·7	195
na ...	35·0	70·8	0·8	0·6	0·4	13·0	265
e ...	27·0	87·0	0·5	0·5	0·1	7·6	150
n ...	30·0	91·1	0·3	0·5	0·4	5·4	125
...	25·0	84·7	0·5	0·8	1·1	13·1	300
...	5·0	86·7	0·4	0·7	0·3	17·3	325
... ...	10·0	84·3	0·4	0·4	0·4	11·4	230
berry ...	8·5	86·8	0·6	1·0	1·0	12·6	247
berry ...	5·0	90·1	0·5	0·7	0·5	6·4	150
to ...	2·1	92·0	0·7	0·9	0·4	3·9	104

Vitamins in Fruits (per oz.).

Fruit	*A I.U.*	*B_1 Mg.*	*Riboflavin Mg.*	*Nicotinic Acid Mg.*	*C Mg.*	*D I.U.*
e	4	0·01	0	0·1	1	0
ot (dried)	473	0	0·12	0·6	0	0
na ...	8	0·01	0·01	0·2	0	0
currant ...	9	0·01	0·01	0·1	57	0
ge ...	28	0·02	0·01	0·2	3	0
on ...	0	0·01	0	0	12	0
e	0	0	0	0	0	0
h (canned)	47	0	0	0	1	0
... ...	38	0·01	0·01	0·02	1	0
e	237	0	0·04	0·6	0	0
to ...	280	0·02	0·01	0·1	7	0

es. These are the dried seeds of leguminous plants, such as peas, beans and lentils: the pea-nut or h-nut is also a pulse. They are all particularly rich roteins, but the protein legumin is not so high in ity as the gluten of cereals, and needs therefore to be plemented in the making of a satisfactory diet. They contain a fair amount of starch and oil, particularly nuts from which arachis oil is extracted for the ufacture of cold-water soap and margarine. Dried es require to be well soaked in water and to be cooked ly -preferably in soft water -and for a prolonged

time to be made digestible. Fresh green pulses are fair rich in the vitamins A, B_1, B_2 and E, but are lacking C and D. Dried pulses though sufficient in B_1 and are seriously lacking in all except this complex, a cannot protect against scurvy and rickets. Howev when legumes are germinated for five days the an scorbutic vitamin C is generated in good value. Boil legumes with soda with a view to improving their colo destroys their vitamins. During recent years the canni of peas, as of other vegetables, has made tremendo strides, very largely the result of scientific research n only on the details of processing and the design of canni machines, but also in the hybridisation of varieties wi desired features of size, colour, food contents and cooki qualities.

Soya bean, a legume of Manchurian origin, sin 1918 has entered the world's markets as a partic larly valuable foodstuff with a very wide range of us It contains a very high percentage of first-class protei (44·2) and some 20 per cent. of fat, which when extract can be used, among other purposes, for the manufactu of margarine. An artificial milk made from soya bea has much the same appearance and composition ordinary milk, with the advantage that it is much le liable to spoilage by bacteria, and may be therefore ke sweet for long periods.

Composition of Pulses (in dried state.)
(per cent.)

	Protein	Fat	Carbo-hydrate	Mineral	Calori per l
Peas	27·5	2·0	66·5	4·0	187
Beans	22·5	1·8	59·6	3·6	156
Lentils	28·1	1·1	64·6	6·2	177
Soya bean... ...	33·7	18·3	32·5	5·0	2003
Peanuts	25·8	38·6	24·4	1·9	249

Nuts. Nuts are various in origin and botani character. Strictly, a nut is a fruit with a ha pericarp within which is a single seed, such as the cob hazel nut and the sweet chestnut, but popularly by

is meant any fruit or seed with a hard case, and so ides examples where the stone or endocarp of drupes been stripped of the outer soft parts, as the walnut, almond and coconut, and where the outermost coat esta of the seed is woody, as the Brazil nut.

uts generally are richly stored with protein, fat and ohydrate, and contain the B vitamins and most mineral salts. The proteins in the main are of high biological e, and the most perfectly of any vegetable proteins replace animal proteins in a balanced diet; almond walnut are best in this respect. Nuts, including pine els and pea nuts, are the mainstay of a complete tarian diet. Coconut shredding or copra, though in oil is, however, poor in most other food principles — eins, salts and vitamins. The oil is used for many strial purposes, including the manufacture of cold er and sea water soaps. Kernels of Brazil nuts are rich in oil—some 70 per cent.—and consequently peculiarly liable to decay in transport and storage.

Analyses of Nuts (as eaten).

(per cent.)

	Proteins	Fats	Carbo-hydrts	Minrls.	Vtmns.	Calors. per lb.
Kernel ...	33·9	49·4	6·9	4·0	B_1	2757
ond	21·0	54·9	17·3	3·1	A B_1	2940
il Nut ...	18·0	70·5	7·4	4·1	B_1 B_2	3360
nut Kernel ...	28·3	57·7	12·0	2·0	A B_1	3312
el	13·2	63·2	14·3	2·7	B_1	3184
nut	4·2	48·5	7·7	0·8	B_1 B_2	2272
nut	6·2	5·4	42·1	0·9	B_1 B_2	1098

VEGETABLES.

great variety of plants and of different parts of them eaten as vegetables. A rough botanical classification egetables commonly used in this country is as follows:

(i) Green leaves—Lettuce, watercress, cabbage, sprouts, spinach, broccoli, mustard and cress, turnip tops and kale.

(ii) Leaf-stalks—Celery and rhubarb.

(iii) Stems—Asparagus, sea-kale.

(iv) Roots—Carrot, parsnip, beetroot, swede, turnip, radish.

(v) Tubers—Potato, artichoke.

(vi) Bulbs—Onion, leek, garlic.

(vii) Inflorescences—Cauliflower, broccoli.

(viii) Fruits and seeds—Cucumber, vegetable marrow, tomato, pulses (peas, beans, etc.), mushroom.

Apart from those vegetables consisting essentially of reserve organs, such as tubers and bulbs, their chief function as foodstuffs is to provide the protective substances—minerals, vitamins and roughage. In ordinary vegetative structures the amounts of available protein and carbohydrates are practically negligible; the cellulose of such foods as cabbage and celery, though considerable in bulk, is not digestible, but yet serves a useful purpose in the intestines as roughage. It is only in the reserve organs, such as the tubers of potato and artichoke, the roots of carrot and beet, and the bulbs of onion and the like, that there is a considerable proportion of available carbohydrates, as starch or sugar, and in the seeds of the pulses—pea, bean, etc.—in addition good proportions of protein and fat. This last group of vegetables is consequently of first importance as a source of energy and to a scarcely less extent also of flesh building material. It is upon the potato that the greater part of the population of this country depends for supplementing bread and their chief supply of calories by way of carbohydrate. The potato, as vegetables go, is also fairly rich in available protein of good grade; it has the further advantage of containing many minerals and most vitamins, and particularly it is admirable as a medium for admixture with a great variety of other foodstuffs such as milk, meat, fish, eggs, etc. Onions and leeks are especially rich in sugars, which are also fairly abundant in turnips and parsnips.

Greens, being leaves chiefly concerned with growth
chemical activity, are peculiarly rich in vitamin C,
also contain some of the B group and A. Raw
d, in great variety according to the season, is excellent
a supply of these essential substances. Greens when
ked, especially in an open container or with soda with
purpose of keeping the colour unchanged, lose much
heir vitamin C. The cooking of vegetables also allows
passage from the tissues of cell sap and its contained
neral salts. If vegetables are boiled in water the salts
s into the water and are often thrown away with it as
ste. It is much better to cook vegetables by steaming,
then the cell sap may be obtained separately, or may
tribute, in a fair proportion to the total cooking
er, in small bulk, and can therefore be available for the
pose of making gravy, soup, or stock.

Composition of Common Vegetables (as eaten).

per cent.

	Protein.	Fat	Carbo hydrate.	Calories per lb.
ichoke	3·4	0·5	12·0	300
troot (cooked) ...	2·3	0·1	7·4	180
bage	1·6	0·3	5·6	143
rot	1·1	0·4	9·3	204
liflower	1·8	0·5	4·7	139
ery	1·1	0·1	3·3	84
cumber	0·8	0·2	3·1	79
tuce	1·2	0·3	2·9	87
shroom	3·5	0·4	6·8	204
on	1·6	0·3	9·9	220
snip	1·6	0·5	13·5	294
ato (Raw)... ...	2·2	0·1	18·4	378
lish	1·3	0·1	5·8	133
ubarb	0·6	0·7	3·6	105
nato	0·9	0·4	3·9	104
rnip	1·3	0·2	8·1	178

Vitamins in Vegetables (per oz.).

	A I.U.	B_1 Mg.	*Riboflavin* Mg.	*Nicotinic Acid* Mg.	*C* Mg.	*D* I.U.
Cabbage ...	85	0·02	0·02	0·1	20	0
Carrot ...	1,730	0·02	0·01	0·2	3	0
Cauliflower ...	0	0·02	0·02	0·2	29	0
Lettuce ...	380	0·02	0·02	0·1	4	0
Onion	0	0·01	0·01	0	3	0
Peas—						
Green ...	47	0·12	0·03	0·2	8	0
Dried ...	19	0·13	0·08	0·6	0	0
Potato	0	0·03	0·02	0·3	2·8	0
Spinach ...	1,230	0·03	0·06	0·1	18	0
Tomato ...	280	0·02	0·01	0·1	7	0
Turnip ...	0	0·01	0·01	0·3	7	0
Watercress ...	475	0·03	0·02	0·5	17	0

EXPERIMENTS ON VEGETABLES.

II. Green Vegetables.

Experiment 1.

To investigate the food materials present in green vegetables.

Test cabbage or cauliflower for protein, fat, starch, cellulo and mineral matters by the methods already described on pag 128-9. Green vegetables will be found to be largely compos of cellulose with a small amount of starch, and very valuab mineral salts. The ash obtained after ignition of the green vegetab may be examined by the ordinary methods of qualitative analys and will be found to contain salts of potassium, sodium, iron a calcium.

Experiment 2.

Experiments to illustrate the cooking of vegetables.

Cook equal portions of cabbage, cauliflower or other green ve table in equal quantities of water for the same length of time the following ways :—

(*a*) Boiling tap water in an open vessel (saucepan or beaker).
(*b*) Boiling tap water in a closed vessel (saucepan with tigh fitting lid).
(*c*) Boiling tap-water to which a little bicarbonate of soda l been added ($\frac{1}{2}$ gram to $\frac{1}{2}$ litre of water) in an open ves
(*d*) Boiling water to which a little acid, e.g., vinegar, has be added, in an open vessel.

hen the vegetables are cooked strain off the water from each compare the appearances of the vegetables and the different ing waters. Test the cooking waters of experiments 1 and 2 litmus paper.

ou should find that the addition of bicarbonate of soda produces t green vegetables and that the cooking water is distinctly ured. The addition of acid spoils the colour of the vegetables gives a brownish tint, while the cooking water is only very tly coloured. You will probably find that cooking in tap r in an open vessel produces quite a good colour and that the ing water is slightly acid to litmus. The colour of vegetables ed in tap water in a closed pan will be found to be inferior to in the open pan, and the cooking water will be distinctly acid tmus.

hese experiments will show that green vegetables are best cooked n open vessel of rapidly boiling water to which a little bicarbonate oda has been added.

Experiment 3.

To examine the green colouring matter of vegetables.

xtract the green colouring matter of cabbage or cauliflower by ping in alcohol. A dark green solution of chlorophyll in hol will be obtained. To a portion of the extract add alkali note the deepening in colour. To a second portion of the act add acetic acid or vinegar and note the rapid change to a vn colour.

he green colouring matter, chlorophyll, of vegetables is soluble lkaline solution. The cooking of vegetables kills the plant cells the chlorophyll present is converted into chlorophyllan with a vnish green colour unless alkali is present. These facts explain results obtained in the previous experiment. The acidity of the king water after boiling in tap water can only be accounted for he formation of acid substances during the cooking. Some of e acid substances, if volatile in steam, will be removed during cooking in an open pan but not in a closed pan. Hence the ior colour of vegetables cooked in a closed pan.

Experiment 4.

examine the volatile products formed during the cooking of vegetables.

oil some of the vegetable with water in a large flask attached condenser and receiver. When sufficient distillate is collected e receiver, test it in the following manner :—

(*a*) Add a few drops of litmus solution to a portion of the distillate. An acid reaction will indicate that volatile acid substances are formed during the cooking of vegetables.

(*b*) To a second portion of the distillate add a few drops of le
acetate solution. The production of a dark bro
colouration will indicate the presence of a sulphide
the distillate. This can be confirmed by making
further portion of the distillate slightly alkaline wi
ammonia and then adding a little sodium nitro-pruss
solution. In the presence of a sulphide a violet colou
tion will be produced.

Experiment 5.

**To estimate the amount of solid matter in a vegetable and the lo
of solid matter during cooking.**

(*a*) Weigh an empty evaporating basin and then place in it so
of the vegetable broken up into small pieces and weigh again. T
difference in weight will be the weight of vegetable taken. No
dry the sample to constant weight in an air oven. From the weig
ings obtained calculate the percentage of solid matter and t
percentage of water.

(*b*) Weigh a further quantity of the same vegetable and th
place in boiling water in a beaker until the vegetable is considered
be sufficiently cooked. Remove the pieces of vegetable and bo
the solution to small volume. When the volume of liquid
sufficiently small evaporate it to dryness in an air oven in a previous
weighed evaporating basin. Finally the basin and contents a
weighed. The increase in the weight of the evaporating bas
represents the loss in solid matter from a known weight of vegetabl
The total solid matter in this weight of vegetable can be estimat
from the previous experiment and consequently the loss in sol
matter during cooking estimated.

This experiment can obviously be extended to compare the loss
in solid matter under different conditions, e.g., with and witho
bicarbonate of soda, and different times of cooking

Experiment 6.

To examine the use of salt in cooking vegetables.

Place equal quantities of the same vegetable in equal quantit
of boiling water in open beakers. Add a little salt to one of t
beakers and leave the other without. Cook the two samples f
the same length of time and at the end of the experiment exami
the condition of the vegetables, compare their flavour and determi
the losses of solid matter in each case. It will be found that t
addition of salt has little effect on the time of cooking or the lo
of solid matter but has a marked effect on the flavour of the vegetab

Experiment 7.

To examine the steaming of vegetables.

or this experiment two identical steamers are required. Place al quantities of water in each, say 1,000 ccs., and about 100 ms of the same green vegetable. To the water in one steamer a little ammonium carbonate (about 1 gram) and cook both ples for the same length of time. Note the condition, colour smell of the two samples of vegetables at the end of the experi-nt.

t will be found that the use of ammonium carbonate gives an roved colour due to the neutralisation of the volatile acids formed ng cooking, that the time of cooking is considerably reduced consequently that there is less loss in solid matter. The etables are unlikely to smell or taste of ammonia. In both cases loss in weight of solid matter will be less than if the vegetables been cooked in an ordinary pan.

2. Roots and Tubers.

Experiment 8.

Different groups in a class should work with one or more of the owing: potatoes, parsnips, turnips, leeks, onions, beetroots and rots.

Food constituents.

Examine for protein, starch, sugar, cellulose and mineral matter. e ash should be examined for metallic constituents by the ordinary thods of qualitative analysis.

Reaction to litmus.

Test the reaction of the raw vegetable to litmus as well as the neral ash. What do you notice and what is its significance?

Structure.

Cut a transverse section and sketch to show three distinct layers. possible examine microscopically.

Cooking.

Examine the effect of different methods of cooking by the methods opted for green vegetables, particularly the loss in solid matter d percentage of water.

3. Pulses and Legumes.

Experiment 9.

Food constituents.

Test a sample of pulses, e.g., lentils, for food constituents. rticularly note the flame test given when the sample is dipped dilute hydrochloric acid and held in the flame on a platinum wire.

What do you infer from this test?

Reduce to an ash, examine the reaction of the ash to litmus and ntify the minerals present.

Experiment 10.

To examine the properties of legumin (protein of pulses).

Crush some peas or lentils and soak in water made *slightly* alkal with bicarbonate of soda. After 24 hours filter off the liquid a test in the following ways :—

(*a*) To a portion add a little acetic acid. Note the format a flocculent precipitate and test its solubility in dil alkali.

(*b*) To a second portion add calcium chloride solution. Filter remove the precipitate formed and test it for protein.

(*c*) Heat a third portion and note whether the protein coagulable.

(*d*) Act upon a fourth portion with rennet solution made slight alkaline. Compare the legumin of pulses with t caseinogen of milk.

Experiment 11.

Loss of food constituents when pulses are cooked.

(*a*) Soak some crushed peas in water for 24 hours. Strain o the liquid and test it for food constituents.

(*b*) Cook the soaked peas in soft water. Strain the liquid fro the cooked peas. Test this for food constituents, particular minerals. On long standing the liquids putrefy ; why is this ?

Draw conclusions as to the loss of food constituents when puls are soaked and cooked in water, and the water wasted. Wh possible uses might be found for this cooking water ?

Experiment 12.

To show the formation of sulphides when pulses are cooked.

Cook some soaked pulses in boiling water containing a piece bright silver—a coin or spoon. Note any discolouration whi takes place. Test a portion of the cooking water with lead acetat solution, and a second portion with ammonia and sodium nitr prusside.

Experiment 13.

To examine the influence of the hardness of water on the cookin of pulses.

Cook samples of soaked peas in distilled water and in hard wat (made hard if necessary). Compare the times necessary for cookin in each case. Explain your results.

Experiment 14.

To examine the cooking of dried legumes.

) Soak 100 grams of dried haricot beans in 250 ccs. of tap water night.

) Soak 100 grams of dried haricot beans in 250 ccs. of tap water aining about 2·5 grams of bicarbonate of soda overnight.

) Weigh out a third 100 grams of dried haricot beans but do soak.

rain off the water in the first two experiments. Evaporate to ness and weigh and examine the residue.

ry the two samples of soaked beans and weigh. Determine the ease in weight in each case.

lace the three samples of beans in saucepans of the same size shape. Add to the first two 400 ccs. of tap water and the third ccs. of water. (This is to make up for the water soaked up by other two samples of beans.) Cover the saucepans with lids boil the water in each for the same time and as nearly as possible he same rate.

ote in each case how long it takes to cook the beans.

vaporate the cooking water to dryness in each case. Weigh the due. Note its taste and smell and determine its chief constituent. ulate the percentage loss of solids in each case. What practical clusions as to the best method of cooking dried legumes can be wn from these experiments ?

CHAPTER XXII.

PRESERVATION OF FRUIT.

Fruit, like other food materials, will not keep indefinite when stored under ordinary conditions. The spoilage fruit is brought about by yeasts, moulds and bacter entering from without, and by enzymes secreted with by the cell protoplasm. Yeasts, moulds and bacter require moisture, air, suitable temperature and appropria food material for their development. The various metho of preservation of fruit consist essentially in the remov of one or more of these necessary conditions, in the destru tion of the micro-organisms, or in the inhibition of enzyme

It happens that the common methods for checkin the activity of the various types of micro-organisms no in use, also destroy the enzymes or restrain them fro effecting chemical changes in the various substances of fruit

Bacteria require for growth a high moisture conten low concentration of substances dissolved in the cell c tissue saps, and a reaction about neutral (pH = 7). Yea needs less moisture, and can tolerate a high sugar co centration and a medium acidity (pH = 5). Mould require but little water and the reaction of the mediu has only a slight effect, but oxygen is needed for growt Fruits in which carbohydrates are by far the most co siderable substance in solution are favourable to th growth of yeasts, and to a less degree of moulds.

The chief methods of preservation of fruits are a follow :—

(i) Drying or desiccation.
(ii) Cold Storage.
(iii) Gas Storage.
(iv) Freezing.
(v) Heat.
(vi) Chemical preservation (jam making).

Drying and siccation. By the removal of water from fruits and the resulting high concentration of the solution in the remaining water, yeasts, teria and moulds are unable to develop and decomposi- is prevented. Enzyme action is completely arrested dehydration. The simple drying of fruit may merely vent the growth of micro-organisms unless the direct s of the sun exercise a germicidal action. Dried fruit rapidly putrefy if allowed to become moist again.

This method of preservation of fruit has been in use for turies, and in early days the heat of the sun was ised for this purpose as it still is in hot countries. In gland artificial heat is necessary and on the commercial le is carried out by causing a current of warm air at °F. to circulate through an apparatus containing the it. In another process cold dry compressed air is sed through the chamber containing the fruit which is surrounded by some hygroscopic substance such as cium chloride, which further assists in the removal of ter from the fruit. Such fruits as apples, pears, peaches apricots may be dried by either of these methods, le figs, raisins and dates may be dried in the oven. the small scale in the home, fruits may be dried by cing them in a moderately warm oven or exposing m to the heat from a stove or fire on wire trays or wood- frames covered with muslin or cheese cloth. Most, wever, of our dried fruit is imported from foreign ntries in which the fruit is sun-dried. This includes rants, sultanas, raisins, apples, apricots, dates, pears,

urrants derive their name from Corinth in Greece where special s are grown which produce small, dark-skinned, luscious, dless grapes. The same variety of vine is grown in the Ionian nds off the west coast of Greece, South Australia, New Zealand the Fiji Islands.

The best quality currant is the Elemé which is a large fleshy fruit h a pleasant sweet taste. For confectionery purposes smaller d fruits are more suitable, for they are more easily distributed formly throughout the mixture. The best known brands are tizzas, Gulf, Patras, Awalias and Pyrgos currants, so called n the districts in which they are grown. The grapes of the currant e are cut in bunches when ripe and placed on drying mats exposed

to the sun. The bunches are turned several times to ensure even drying. When dried the stalks are removed by hand or machinery, sifted, packed in casks and exported. Good quality currants should be clean, bold and fleshy with a blue to black shade of colour and should be as free as possible from shrivelled fleshless fruit and red coloured sour berries which may easily spoil the flavour of cakes etc.

Dried currants should not be confused with English currants which are not grapes but the fruits of deciduous shrubs, Ribes nigrum, R. rubrum and R. alba (black, red and white). English currants are used for jam, fruit dessert, jellies, as a throat gargle and in throat lozenges.

Raisins and Sultanas like currants are the dried fruits of various varieties of the grape vine—*Vitis vinifera* –and are produced in a similar manner. They are grown in regions bordering the Mediterranean Sea—Sicily, Ionian Isles, Crete, Cyprus—and the islands of the Aegean Sea: Persia, Afghanistan and California also produce large quantities of raisins. As with currants the ripe grapes are spread on fibre mats or wire frames. The fibre mats are placed in the ground, and the wire frames in tiers in a wooden framework. The bunches of fruit are turned occasionally so that all parts are equally exposed to the sun and air. Water is evaporated out of the grapes and the sugars, tartar and other solids concentrated to a point at which micro-organisms are unable to utilise them as food even though the water content is as high as 30 per cent. Raisins are produced from Muscatel grapes and sultanas from a seedless variety of yellow grapes.

Dried Apples, Apricots, Pears, etc.

Australia, New Zealand, California, Canada and Natal produce large quantities of apples, apricots, pears, etc., for export either in the ripened condition or dried. Fruits such as apples and pears are first deprived of their cores containing the seed pips in their stout cellulose casing, and are then cut into discs. Stone fruits such as apricots and cherries are deprived of their stony kernels before drying. The fruits are then exposed to the air and strong sunlight which exert an antiseptic as well as a drying effect upon the fruit. When completely dried the fruit is packed in lined wooden cases and stored in a cool dry place. Before use the dried fruit should be soaked in plenty of cold water for a long time (24-48 hours) and then boiled slowly in the water in which they have been soaked until the fruit becomes plump and tender. The sugar used should be added a few minutes only before cooking is complete. The fruit re-absorbs a very considerable amount of water and retains its original flavour, aroma and food ingredients in an only slightly impaired condition.

Fruits such as apples pears and plums can be simply and inexpensively dried at home. Wooden frames or wire trays covered with cheese cloth or muslin can be used to carry the fruit which should be placed in a moderately warm oven. Ripe fruit dries

re quickly than unripe fruit and has a better colour and flavour
en dried. **Apples** should be peeled and cored and cut into discs
ut ¼-in. thick. The discs should be placed in a single layer on
trays and dried in the oven at a temperature between 120-150° F.
e process takes between 4–6 hours and when complete the dried
le rings should be left for twelve hours, then packed and stored
a dry place. To prevent the apple rings from turning brown when
osed to the air they may be sulphured. This can be done on a
all scale by burning some sulphur on a tin lid and inverting a few
le-mouthed jars over the fumes of sulphur dioxide formed.
en each jar is full of fumes it is turned right way up and covered
h a plate. The apple rings are placed in the jars immediately
cutting and shaken up and left for 10 to 15 minutes. The rings
then removed and dried.

Pears should be peeled and cut into quarters, cored, and placed
mediately in a salt solution (1 oz. salt to 1 gallon water) for about
minute. This treatment is necessary with pears to prevent
colouration on exposure to air. Unlike apples, the more delicate
vour of pears is impaired by sulphuring. When taken from
salt solution superfluous moisture is removed by shaking, and
fruit dried on trays in the oven at a temperature of 100° F. which
gradually raised to 150° F. Drying takes between four to six
rs.

An alternative method is to place the pears after cutting into
arters and coring into a sugar syrup containing 2 lbs. of sugar to
allon of water. The action of a strong solution of cane sugar on
it is in effect the same as that of drying, the cells of the micro-
anisms being destroyed by plasmolysis, and the cell sap of the
it drained of much of its water by the process of osmosis as
ctively as if it were evaporated, until its osmotic pressure
alled that of the sugar solution. The fruit is stewed until
der, the syrup drained off and the fruit then dried by placing
n a cool oven at a temperature of 110° F. which is gradually raised
150°F.

nes. Any variety of plum or damson which can be dried without fermenting can be used for the preparation of nes. The fruit should be fully ripe so as to have developed a d flavour. To obtain a good product the plums should be dipped o a lye containing 1 oz. of caustic soda to a gallon of boiling water. is treatment removes the bloom and softens the skin so that the ter can more easily escape during drying. The plums should then washed in cold water, spread out on trays and dried at a tempera- e of 120° F. which is gradually raised to 160° F. The heating uld be gradual or the plums will swell up and burst. They are ecially liable to do this if the bloom has not been removed by ping in lye solution or the plums have not been pricked before ing. The drying is a slow process and takes at least 30 hours. en completely dried the plums should have lost about two-thirds their weight and their texture should be firm but springy and brittle. Prunes are sometimes dipped in hot water containing

glycerine to give them a glossy appearance. Although there are a few districts in England which prepare their own prunes the majority are imported. While fresh plums contain 75-80 per cent. moisture prunes contain only about 18-20 per cent. moisture and 40-50 per cent. sugars and about 2 per cent. fruit acids. Before being used prunes should be washed in cold water, and then soaked in cold water for twelve hours and cooked in a slow oven.

(ii) Cold Storage. This is only a temporary method of preservation. Micro-organisms are not destroyed by submitting them to even very low temperatures, but they are held in check and prevented from multiplying. The micro-organisms are liable to become active and set up decomposition when restored to normal temperatures. Fruits such as oranges, bananas and apples can be kept in good condition for a considerable period by storing them at low temperatures round about freezing point.

It might be thought that the different species and varieties of fruits would agree fairly closely in the best temperature for their preservation, but investigation has shown that it is far otherwise. Thus the best temperatures of storage for different varieties of apples are :— Newton Wonder, 34°F. ; Bramley Seedlings, 37-38 F. and King Pippin, 40°F. The banana, a warm temperate fruit, stores best at 54-57°F., but the mango, a typical tropical fruit, best at 36°F.

The preservation of fruit during transport and storage is governed by the fact that the fruit is a living organism and as such is constantly engaged in chemical changes as well as in respiration —absorbing oxygen and breathing out carbon dioxide. Ripening of fruit consists mainly in particular chemical changes which can be slowed down, or largely halted by low temperature, as in cold storage, or by the more modern process of gas storage.

(iii) Gas Storage. This depends upon the fact that fruits being alive continually exhale carbon dioxide gas and water vapour. This respiratory activity and its accompanying chemical reactions, can be delayed by increasing the concentration, or the back pressure, of the carbon dioxide in the atmosphere of the storage chamber. This is the basis of the modern method

gas storage, which has made practicable the transport vast quantities of fruit from Australia and elsewhere the home market. The fruit is stored in an atmosphere ntaining a certain percentage of carbon dioxide, its lue and the optimum temperature varying for different nds of fruit. Gas storage is not only practical for the nsport of imported fruits, but is being increasingly opted for the storage of home grown fruit. During 34 the numbers of commercial gas stores in Great itain increased from 12 to 40 and the number probably ubled in the course of the next year.

v) **Freezing.** Fruit may be frozen in view of a variety of subsequent uses: for immediate nsumption as a dessert; for cooking; and for storage bulk for catering, canning or jam making, so making ese industries all the year round instead of seasonal cupations. Jams or canned goods made from frozen uit differ in no respects in appearance and flavour from ms made from fresh fruit. Preservation by freezing as the advantage over that by ordinary cold storage at the ripening changes due to the enzymes continually eing produced in actively living cells are for all practical urposes stopped, so that the fruit can be kept unchanged or much longer periods. Freezing largely eliminates the sk of spoilage by moulds and bacteria which attends rdinary cold storage.

In freezing, ice is formed in the tissues which are thus xtremely desiccated. Chemical change is considerably educed, and the chemical organisation of the protoplasm s profoundly modified so that enzymic reactions take lace, which do not occur in the uninjured living material, s, for example, in the browning of frozen cherries and lums.

According to their reaction to freezing English fruits nay be divided into two groups. The first group, ontaining raspberries, gooseberries, currants (red and lack), bilberries, blackberries, sour red cherries and hubarb, can all be frozen and stored without any special reatment at a temperature of 14° F. for six months or nore, without much loss of colour, flavour or aroma.

The second group, includes fruits which require special precautions for their successful storage when frozen. Among such fruits are plums, sweet cherries and strawberries, and with them freezing and storage at 14°F., even for short periods of a few weeks, results in marked discolouration and loss of flavour by enzymic action. One useful method of retarding enzymic changes in fruits generally is to place the fruit in syrup, and in difficult cases, as of plums and cherries, partly to cook the fruit in water or syrup before freezing, and as in strawberries by quick freezing at −50°F followed by storage at 0°F. or below.

(v) Heat. Sterilisation by means of heat is one of the most effective and convenient methods of preservation of fruit. Yeast cells and mould spores are easily destroyed by exposure to a temperature of 165°F. for a few minutes. Enzymes are highly sensitive to increases in temperature and are destroyed during sterilisation. Bacteria in the vegetative cell form are generally destroyed by heating for a few minutes to the temperature of boiling water, but spore-bearing bacteria can exist after boiling for several hours. They are, however, highly sensitive to acids ; the acids so frequently present in fruit have therefore a powerful antiseptic action.

The two common methods of preservation of fruit by heat are bottling and canning.

Bottling. Soft fruits, except gooseberries, should be of good colour, ripe and firm. Gooseberries should be bottled when green and slightly under-ripe. The majority of stone fruits should be firm-ripe. The fruit should be picked while dry and preserved as soon as possible. It is advisable to grade the fruit according to size and ripeness, for the time necessary for cooking will depend to some extent on the size of the fruit. The two commonest types of bottles in use for the preservation of fruit are clip bottles and screw band bottles. Clip bottles have glass, aluminium or lacquered tin lids which are held in position during sterilisation by a metal spring clip. When the pressure inside the bottle increases during the heating the spring clip allows the lid to be lifted slightly and steam and air escape. During cooling the spring clips hold the lids firmly in position until a partial vacuum is formed. Screw band bottles are provided with lacquered tin or aluminium screw

ids which fit loosely during sterilisation to allow the escape of am and air. During cooling the bands are screwed down tightly as to hold in place until the vacuum is formed; then rubber gs are inserted between the bottle and the lid to ensure hermetic ling.

Before use the bottles should be perfectly cleaned in order to rilise them thoroughly. The fruit should be packed as tightly possible and the bottles well filled. Either water or sugar syrup ay be used as a covering liquid. Of the two the sugar syrup is e better as the sugar impregnates the fruit during sterilisation d storing, and helps in the preservation of the fresh fruit flavour. e most suitable strength of sugar syrup is one containing 8-12 ozs. r pint of water.

The rubber rings, lids and clips or screw bands are now placed in sition and the bottles placed in the steriliser. The type and size vessel used for containing the bottles and boiling water will depend on the number of bottles to be sterilised but, in any case, the ttles should stand on a false bottom of wooden laths or wire tray that they do not touch the hot bottom of the steriliser. The ttles should be completely covered with water to ensure uniform ating, and the use of a thermometer is advisable if consistent sults are to be obtained.

When the bottles have been sterilised for the necessary time at a itable temperature, they should be removed and allowed to cool a wooden table or rack. When cold, the clips or screw bands are moved, carefully dried and smeared with vaseline. Before replacg the clips or screw bands the bottles can be tested to see if there is good vacuum by lifting them by the lid. If the lid remains firm ere is a good vacuum and the fruit will keep.

Bottled fruit may also be sterilised by the dry heat of an oven stead of by boiling water. The fruit is packed in the bottles ithout water or syrup. The lids are then placed on the bottles ithout rubber rings, clips or screw bands and the bottles placed in moderate oven for three quarters of an hour to an hour until the uit has shrunk and has a cooked appearance. When removed om the oven the bottles are immediately filled to the top with oiling sugar syrup, and the rubber rings, lids, clips or screw bands aced in position and the bottles left to cool.

While vacuum bottles of the screw band or spring clip type give e best results ordinary wide-necked bottles or jam jars may be sed if care is taken to seal them well enough to prevent the access of ould, spores and yeast cells. Acid fruits such as plums, damsons d gooseberries, which are easily sterilised, are most suitable when acuum bottles are not available. When sterilised in water the rs or bottles used should all be of the same height, and placed on a lse bottom in a pan or boiler with the cold water reaching to the oulder of the jars or bottles and the pan or boiler covered with a d to keep in the steam. The temperature of the water should be ought to simmering point in about an hour and allowed to simmer

for about 3 minutes. The jars are then removed one at a time and sealed as quickly as possible.

When sterilised in the oven the fruit is covered to prevent scorching and syrup added after removal from the oven as with vacuum bottles.

Various methods are used for sealing the bottles and jars, among which the following may be mentioned :—

(*a*) Oil, Fat or Wax.—Olive oil, medicinal paraffin, paraffin wax or clarified mutton or beef fat may be used. The oil, melted wax or fat is poured carefully over the fruit to a depth of a half to one inch and a piece of paper tied over the mouth to keep out dust.

(*b*) Corks.—If a good fitting cork or bung is available it may be used but should be perfectly clean and sterile, and must on no account be small enough to be drawn into the bottles as the fruit cools and a vacuum is formed. No ordinary corks are really air-tight and should be covered with melted wax. Alternatively the corks may be kept wet by storing the bottles on their sides or even inverted.

(*c*) Cloth and Wax.—Pieces of white calico are cut into squares sufficiently large to tie over the bottles or jars. The tops of the bottles or jars are first covered with a piece of grease-proof paper and the cloth then painted over with a melted mixture of one ounce beeswax, one ounce vaseline and eight ounces resin.

(*d*) Paper.—Several layers of paper cut to the right size and pasted together may be used. The outside of the neck of the bottle or jar should be coated with paste or gum and the paper covers firmly stuck to the sides to give an air-tight seal. Cellophane is coming increasingly into use as a covering for bottled fruits and jams.

Canning of Fruit. The cans are packed with graded fruit in the same ways as bottles and then filled with water to within about quarter of an inch from the top in order completely to cover the fruit. Boiling water or sugar syrup is preferable, for this shortens the canning process and helps to give a better product than is obtained by gradual heating in cold water. The boiling water or syrup will be considerably cooled by the cold fruit and can, but sufficient steam is formed inside the can to replace nearly all the small amount of air left inside the can after packing. The lid is soldered on and the vent hole through which the steam and air escape is sealed (tipped) with solder.

When cold or warm water is used the filled can may have its lid soldered on, but before tipping the can must be heated in the steriliser for five to fifteen minutes. The cans should then be taken out and tipped immediately. In exhausting the cans by either method it is essential that enough air should be driven out so as not to cause undue pressure inside the cans during processing. This is accomplished by both methods so long as the can is finally sealed at a temperature above 170° F. Processing, i.e., heating to sterilise

l at the same time cook the fruit, is best done immediately after
ling the cans for the cooling effect on the boiling water or steam
l thus be less.

The cans are removed from the steriliser and should be carefully
mmed, in case a leak should have arisen during processing. The
s are then cooled in cold water to prevent over-cooking and
sequent mushiness and finally stored in a cool dry place.

The canning of fruit at home has been much simplified by the
roduction of the so-called sanitary cans. In these open-ended
s no soldering is necessary for the cans are sealed by a hand
sealing machine for domestic use or by power seamers on the
mmercial scale.

The nutritive value of canned goods, generally, prepared
modern methods is little if anything less than that of
e fresh goods, and if account be taken of the fact that in
nned goods there is little or no waste may be actually
ppreciably higher. There can be no question that on
e balance the proportionate amounts of protein, carbo-
drates and fats are higher in canned goods than in
ther raw or home cooked goods. In the matter of
tamins and mineral salts, particularly the former,
ere has been some degree of uncertainty, which is now
ing removed by investigations into the vitamin contents
canned goods. The special nutrition committee of the
ritish Medical Association in the report of 1933 reported
at tinned goods, in particular tinned fruits and tomatoes,
ford a convenient and not too expensive means of
btaining certain vitamins and minerals during seasons
hen fresh fruit is unobtainable or expensive. American
searches go to show that the canning process, so long
cooking is carried out in absence of air, has no appreciable
ffect on the vitamins present in the raw materials, and
at canned foods may be stored for long periods—toma-
es for 3 years and strawberries for 16 months—with
tle or no loss of their vitamins. As for the mineral
lts, there is no question whether they are present in any
ss amount or are less available in canned fruits than
the corresponding raw fruits.

i) Preservation by Chemicals. At one time it was common practice to preserve fruit by the addition to it of chemical preservatives such as oracic acid, borax, sodium benzoate, sodium salicylate

and formalin. The use of such preservatives is now prohibited. Most fruit is now preserved by means of sugar in the form of jams, jellies, candied peels and glacé or crystallised fruits.

Jams and Jam-making.

Pectin. Fresh fruit contains fibre, water, sugars, fruit-acids and a gum-like product known as pectin. It is this pectin which is of the greatest importance in the preparation of jam and to which the setting on cooling is due. Successful "gel" formation is dependent upon the extraction of as much pectin as possible from the fruit, and in this connection it has been found that the presence of fruit-acids is necessary. Fruits such as plums, damsons, currants and gooseberries are easily made into jam since they contain large proportions of both pectin and acid. On the other hand, ripe strawberries and cherries contain very little acid and also only a relatively small proportion of pectin, and are consequently difficult to convert into jam. This also explains the frequent addition of such acid substances as lemon juice, tartaric acid, citric acid and gooseberry or red-currant juice to fruits deficient in acid. The presence of acid in fruit also improves the colour and flavour of the jam and prevents "graining" or crystallisation of the sugar in the jam on storing. This graining is prevented by the "inversion" of some of the cane-sugar to glucose and fructose during the boiling of the jam. Strawberries, cherries and rhubarb, which are deficient in pectin and only set with difficulty, can be made to form excellent jam by the addition of pectin from other fruits. This can be done by making the jam of two fruits, such as strawberry and apple, or the use of home made pectin or commercial pectin preparations. Home-made pectin stock can be prepared from such fruits as gooseberries, red-currants or apples by simmering 3 lbs. of fruits with one pint of water until tender. The fruit is then mashed and strained through a scalded jelly bag and left to drain. After draining, the pulp in the jelly bag is again simmered for about an hour and finally strained. The two extracts thus obtained are then mixed. The mixture

be tested for pectin by pouring a sample into methyl-
d spirit. Pectin is insoluble in alcohol and is precipi-
ed as a jelly-like clot. If only a poor clot is obtained
extract should be further concentrated until it yields
ood clot when tested in this way. Finally the extract
ottled and stored for use with fruit poor in pectin.

t is now possible to obtain commercial pectin prepara-
ns such as Certo and Zett. When these are used the
e of boiling is very much reduced, the yield of jam
greater, the fresh fruit flavour and colour are more
dily preserved, and a well-set jam is ensured. Such
ncentrated pectin preparations should, however, be
d with care and the directions usually enclosed followed
curately, otherwise the jam will be too stiff or the
licate fruit flavour ruined.

m-making. The conditions necessary for successful jam-making are briefly as follow. The
st consideration is, of course, the fruit. This should be
rfectly fresh and have attained full-size without being
er-ripe. It is at this stage that fruits are richest in
ctin and acid, while over-ripe fruits contain a diminished
hount of pectin and acid, and are liable to mould growth
d to lose colour and flavour. After the removal of
desirable fragments such as stalks, leaves and calices,
e fruit should be cooked for some time before the
gar is added. The length of time taken for this cooking
ries according to the fruit used : from 10-15 minutes
th such fruits as raspberries, to 30-45 minutes with
dition of water in the case of plums, damsons and black-
rrants. During this preliminary cooking the cell walls
the fruit are broken down and pectin extracted, and
me water is lost by evaporation. In the case of fruits
ficient in fruit-acids to which the addition of some
ditional acid is desirable such should be added at this
ge, for it assists in pectin extraction. This preliminary
oking of the fruit is complete when a good pectin clot
obtained with the following test. A teaspoonful of
ice free from seeds and skins is placed in a glass and
ree teaspoonsful of methylated spirit added to it. The
ixture is shaken gently and left for a minute. If the

fruit contains sufficient pectin a transparent jelly-lik clot of pectin will be formed and when poured from on glass into another remains in one piece. A poor cl may divide into two or three lumps, and a very poor cl into numerous small pieces.

Provided the fruit has given a good pecti clot in the tests just described it is now ready for th addition of sugar. The most suitable type of sugar is good quality granulated sugar. It makes no differenc whether it is cane sugar or beet sugar, provided it is o good quality. Once the sugar has been added the jam should be stirred until all the sugar has dissolved, and th jam then boiled as rapidly as possible. During boilin the stirring should be reduced to a minimum, otherwis air-bubbles and scum are liable to become mixed up wit the jam and spoil its appearance. This boiling perio will vary from about three to twenty minutes accordin to the kind and quantity of fruit, as well as the shape an size of the pan. The object is to reduce this period o boiling with sugar to a minimum in order to produce jam with a fresh fruit flavour, good colour and firm set If boiled for too long the setting qualities of the pecti will be deteriorated since it cannot withstand prolonge boiling with acid. In addition, too prolonged boilin may caramelise some of the sugar and consequently spoi both the flavour and colour of the finished jam. On th other hand, if the jam is not boiled long enough a insufficient amount of sugar will be inverted and th jam will " grain," i.e., crystallise and become sugary o storing. Further, the pectin, acid and sugar in the jam must be in correct proportions if the jam is not to set to thick sticky mass. The proportions are reached by th loss of moisture by evaporation during boiling.

While it is impossible to lay down any hard and fas rules as to the amount of sugar which should be used fo every type of fruit it is generally true to say that the bes results are obtained when 60 per cent. of the final weigh of the jam is due to added sugar. The actual percentag of total sugar will be higher than this on account of th natural fruit sugar present in the fruit and the loss i

ight which takes place by evaporation. With less rcentages than 60 the jam will be liable to ferment. nile with more than 65 per cent. of sugar the jam will too sweet and liable to crystallise out.

Another point about sugar is that when added to the it it has a hardening effect upon it, due to absorption water by osmosis. For this reason fruits with hard ins, such as damsons and black-currants, should be oked until thoroughly soft before the addition of sugar, nile soft fruits such as strawberries are better covered ith sugar overnight as this toughens them and helps to ep them whole when made into jam.

STS.—The following tests may be made to find when the jam has ached setting point :—

(i) COLD PLATE TEST.—A sample of the jam is poured from a oden spoon on to a cold plate. When the jam has reached setting int the surface of the sample should set quickly and crinkle when shed with the finger.

(ii) FLAKE TEST.—A sample of the jam is taken out on a clean oden spoon and turned horizontally until the sample is partly oled. The jam is then allowed to drop from the edge of the spoon d if the drops run together into flakes which break off cleanly tting point is reached.

(iii) TEMPERATURE TEST.—Provided a suitable thermometer, e.g., ating dairy thermometer or sugar boiler's thermometer, is available is is the most reliable test. When the jam boils at 220° F., the gar has reached the correct proportion and the jam will set on oling.

(iv) WEIGHT TEST.—This test consists in weighing the pan and s contents (without spoon) on a suitable spring balance, until the quisite weight is reached. The requisite weight is reached when e weight of added sugar forms 60 per cent. of the weight of the m. Thus if the recipe contains 6 lbs. of sugar setting point is

ached when the weight of jam reaches $\frac{6}{1} \times \frac{100}{60} = 10$ lbs.

(It must be remembered, of course, that the weight of jam does ot include the weight of the pan in which it is boiled.)

When setting point is reached the jam should be removed from e source of heat and any scum quickly removed. The jam should en be quickly poured into clean, dry, warm jars, which should be led quite up to the top to allow for considerable shrinkage on oling. After filling, a small wax circle should be placed on the rface of the jam in each jar, which should then be tied down and ored in a cool dry dark cupboard. In the cases of strawberry

jam and marmalade it is advisable to allow the jam or marmalade to cool in the pan until a thin skin forms on the surface. The jam should then be gently stirred and poured into the jars. By doing this the liquid thickens somewhat and the fruit is less likely to rise to the surface after placing in the jars.

Fruit Jellies. The preparation of fruit jellies depends upon the same principle as that of jam already outlined. It is just as essential that the pectin, fruit acid and sugar should be in correct proportions if a proper jelly is to be obtained. With the exception of strawberries and cherries, which are deficient in pectin and acid, all the common fruits, as well as such wild fruits as elderberries, blackberries, sloes and crab-apples can be used for jelly making.

The fruit should first be washed, but it is unnecessary to remove stalks, leaves, skins, calices, etc., since they will be removed during straining. It is an advantage in the case of large fruits such as apples and plums to cut them into small pieces. The fruit is then cooked in water, the amount of water depending upon the type of fruit. The cooking should be slow and the fruit simmered until tender, when the maximum amount of pectin and acid will be extracted. The test for pectin is the same as that for jam, and when a good clot is obtained the pulp is strained. The straining is done through a jelly bag of felt or flannel which should be previously scalded. Straining is complete when no more liquid passes through the jelly bag.

The juice is now heated and skimmed, and sugar added at the rate of one pound per pint of juice. The juice is stirred until all the sugar is dissolved, and then boiled as rapidly as possible without stirring. The jelly will set as in the case of jam when the added sugar content has reached 60 per cent. The same tests can be used as in the case of jam (except the weight test) or a hydrometer may be used. The jelly will set when the reading on a Beaumé hydrometer reads 32, or a Balling hydrometer reads 59. The hydrometer should be placed in a sample of the jelly poured into a narrow vessel or tall glass.

When setting point is reached the hot jelly should at ce be poured into clean, dry, warm jars until completely ed. Wax circles should be placed on the surface of e jelly while still hot and the jars tied down after oling. The jellies should then be stored in a cool, y, dark cupboard.

armalade. The preparation of marmalade from such citrus fruits as oranges, lemons, grape-fruits d limes, is so similar in method and principles to jams d jellies that the following details only need be entioned.

The thick rinds of citrus fruits require boiling for at ast two hours, and the addition of water is essential uring the cooking. It is important that the white inner in or " pith " of the citrus fruit should be cooked along ith the rest of the fruit since the pectin is derived from and not from the juice. If considered desirable, this hite inner skin can be placed in a muslin bag and cooked ong with the marmalade, and then taken out before the gar is added. In this way the valuable pectin is tracted without spoiling the appearance of the marmade by the presence of white pith in it.

ommercial Jams. On the commercial scale fresh fruit as it arrives at the factory is freed om stalks, leaves, calices, etc., by " slubbing," " snibing " or plucking by hand in the case of delicate fruit uch as strawberries, and by mechanical appliances in ther cases. The boiling of the fruit is carried out in eam-heated vessels, usually made of copper. The pans e generally capable of boiling 100 lbs. of jam at a time nd are surrounded in their lower half by a concentric essel into which steam can be injected for heating urposes. The steam pressure is adjusted to give a boiling me of about 10 minutes. The setting point is determined as in the case of home-made jams by the flake test nd weight test, and also the temperature test. The emperature in commercial practice is 223 F. instead of 20 F. as this gives a more solid jam more suitable for ansport. A further test is the refractometer test by

means of which the concentration of soluble solids i determined. Setting point is reached when the jar contains 70 per cent. soluble solids.

When the boiling is complete, the jam is cooled an stirred gently until the solid pieces of fruit no longer floa It is then covered with a circle of waxed tissue an stored. The tie-over covers of commercial jams are no usually placed on the jar until the jam is sent from th factory. By keeping the jars uncovered except for th wax tissue they can be more easily examined and recon ditioned if necessary.

The composition of jams varies, but the followin table gives a general average composition of jam.

	per cent.
Water	28
Sucrose	36
Invert Sugar ...	33
Fruit acids	0·75
Pectin	0·5–·75
Seeds & Fibre (exclusive of stones).	1–2

Although there are no legal requirements for jam the Food Manufacturers' Federation and the Society o Public Analysts have agreed that all commercial jams shall contain not less than 68·5 per cent. of total soluble solids as shown when cold by a refractometer. Standards have also been fixed for first and second quality jams on the basis of the weight of fruit in 100 lbs. of the finished product: "Full Fruit Standard" and "Lower Fruit Standard" respectively. The minimum fruit content is 35–42 per cent. according to the variety o fruit in first quality jam, and 20 per cent. in second quality.

The gross adulteration of cheap jams is not now so widespread as was once the case, though glucose is stil

quently used to prevent graining of commercial jams
l a little artificial colouring matter is sometimes
ded to give the jam a more attractive appearance.
The only preservative that can be legally added to
n is sulphur dioxide. This can be used either as a
ution in water (sulphurous acid) or as calcium or
assium bisulphite. The amount of sulphur dioxide
st not exceed 40 parts per million.

Fermentation of Jam and Mould Growth.—
ere are many opportunities for fermentation and
uld growth in jam. Sugar when in dilute solution is
excellent food for microbes, yeasts and moulds, even
ugh when concentrated it acts as an antiseptic.
rmentation of jams, particularly of strawberry and
ck-currant, occurs under one or other of the following
cumstances: (i) use of unsound fruit; (ii) a poor
owing season, such as a wet muggy summer predisposing
it to attack by micro-organisms; (iii) use of low grade
gar; (iv) use of unclean adulterates marrow, figs,
go and glucose; (v) insufficient boiling and inversion
the cane sugar.

Graining of Jam.—The appearance of jam is
casionally spoiled by some of the sugar present in
crystallising out from solution and turning the
m sugary. This graining takes place because either
o much cane-sugar has been used, or too little of it has
en inverted during boiling. The presence of invert
gar to the extent of 30 per cent. reduces this tendency
crystallise to a minimum. The invert sugar is formed
ring the boiling of the jam by the fruit acids, and the
nount of inversion which takes place is dependent upon
e time of boiling and the degree of acidity or pH of
e mixture. The most suitable pH value for jam is 2.4,
this is effective for both pectin extraction and sugar
version. The addition, often found advisable, of citric
id, tartaric acid, lemon juice, red-currant or gooseberry
ice serves to increase the acidity to this amount. In
e cases of fruits containing a relatively high proportion
natural acid, e.g., red-currant and green gooseberries
o much inversion may take place even with very short
iling, and graining may take place due to glucose and

not sucrose, as is usually the case. With such fruits the pH value can be increased, i.e., the effective acidity reduced by the addition of a little sodium bicarbonate or sodium citrate to act as "buffer."

Candied Peels, Glace and Crystallised Fruits. The chief candied peels are those of the lemon, orange, citron and lime. The methods of preparation are similar in each case, though there is some variation in the strength of sugar syrup used and the times taken for the various processes. It will be sufficient to describe the preparation of lemon peel, for this is typical of the others. A special variety of lemon with a thick rind grown in Italy and Sicily is most suitable. The fruits are cut in two transversely and the pulp extracted. The "caps" are then soaked in brine for several days to remove undesirable matters and to open up the rind to render it more porous. The caps are next transferred to cold water to remove the salt, and then placed in tanks or tubs of weak sugar syrup. Here partial fermentation takes place and a certain amount of sugar is absorbed by the rind. The caps then pass successively into stronger and stronger syrups until saturated. They are then drained and air-dried and become the so-called "drained caps." The drained caps are candied by heating on wire trays to a high temperature for several hours. The heating sets the sugar, hardens the caps and partly sterilises them. They are finally cooled in a cold dry room and packed ready for use.

Glace and Crystallised Fruits and Flowers. Included under this heading are not only such fruits as cherries, currants, apricots, plums and pears but also the rhizome of ginger, the stem of angelica, and the petals of sweet Parma violets or roses.

All fruits should be in perfect condition and just ripe. Stone fruits must have their stones removed. They are cooked in weak sugar syrup until soft, and then allowed to drain. The fruit is afterwards dipped or rolled in melted sugar. This gives a coating of sugar on the outside of the fruit, which is crystallised by subjecting it to dry heat.

The rhizome, i.e., underground stem, of ginger (Zingiber icinale) is first cleaned and then cooked in weak sugar rup until soft. It is packed in syrup in stone jars. ound ginger is prepared by cleaning and afterwards nding the dried rhizome.

Angelica (Angelica archangelica) is a perennial umbelli- rous plant which grows wild in swampy districts in this untry, and is also cultivated. The stem is candied a similar way to candied peels, and used for similar corative and flavouring purposes in confectionery.

Sweet Parma violets and rose petals are crystallised by acing them on wire frames placed one above the other tiers. Under the lowest frame is a tray to catch excess rup which is allowed to drip through the frames until e petals are saturated. Finally, the petals are dried gentle heating or exposure to the sun.

Experiment 1.

illustrate the conditions necessary for successful jam and jelly making.

Cut up an apple into small pieces and boil with a little water until e apple is reduced to pulp. This heating should take about minutes. Take care not to burn the apple. Strain the mixture rough muslin. Test the strained liquid with litmus paper and hling's solution. To a portion of it add methylated spirits. If a lly-like clot is formed it is an indication of the presence of pectin hich is insoluble in alcohol.

Divide the remainder of the extract into five equal portions in aporating basins.

(*a*) Set on one side without further treatment.

(*b*) Heat to boiling, testing from time to time, to see if the liquid will set on cooling.

(*c*) Add about half the bulk of solid cane sugar and heat to boiling. Test as in (*b*).

(*d*) Add a little solid tartaric acid and heat to boiling. Test as in (*b*).

(*e*) Add about half the bulk of solid cane sugar and a little solid tartaric acid and heat to boiling. Test as in (*b*).

Note in which cases jellies are obtained on cooling. Your results ould show that for successful jam or jelly making, pectin, fruit id and sugar are necessary, and that the mixture must be boiled order to invert some of the cane sugar.

CHAPTER XXIII.

BEVERAGES.

Tea. Tea has been used as a beverage in China at least since 2700 B.C. It was introduced into this country early in the Stuart period, but it was not until 1660 that it came to the notice of Pepys.

Tea consists of the dried leaves of a shrub, Camellia thea, grown in China, India, Ceylon, Java and Japan. Originally all tea on the London market came from China, but since 1833 it has come increasingly from India, and since 1877 from Ceylon also.

The tea plant is kept down by severe pruning to a low shrub, and its leaves are plucked at intervals during the season. The size of the leaf varies according to age and position on the twig and determines the grade of tea. The finest tea is the small top half of the twig and the bud—*Flowery Orange Pekoe*. Other grades are *Orange Pekoe*, the second leaf, long and wiry; *Souchong*, two or three larger leaves further down the twig and *Congrou*, leaves below the Souchong. The different grades of leaves are plucked from the same bushes at the same time.

The process of manufacturing tea is briefly as follows:—

i. **Withering:** Here about half of the water in the leaf is dried out by exposing the fresh leaves on mesh trays in a well ventilated shed.

ii. **Rolling:** The individual leaves are rolled either by hand as in China, or by machine as elsewhere.

iii. **Fermenting:** The rolled and bruised leaves are spread out in cool, dark, ventilated rooms and covered with damp cloths and allowed to ferment for several hours. The colour darkens and the aroma is developed. Lightly fermented tea gives a pale and pungent infusion; fully fermented tea gives one that is deep and flavoured. Green tea is not fermented.

iv. **Firing:** Currents of hot air dry the leaves, stop fermentation and make the final crisp and twisted tea.

Tea is generally imported into this country as "originals" or unblended tea and is afterwards blended by

lesalers to suit the tastes of the retailers, or rather r customers, in different districts, to a very large extent ender upon the character of the drinking water, ther it is hard or soft. Roughly, the grades of tea ked in a grocer's shop follow the course of the prices; so-called cheaper teas on the balance of flavour, na and colour of infusion are not the more economical. rder to make tea satisfactorily, the water should have been brought to the boiling point: the pot, preferably of earthenware, already hot: the leaves crushed and ken so as to expose the largest surface and as speedily ossible to the boiling water, and infusion should be wed to continue for three minutes or so for Indian and for five minutes for China tea. An infusion that been long standing has lost much of its quality by excessive amount of tannin then extracted. Caffeine tea oil, the characteristic ingredients of tea, are easily racted by infusion, and are largely absent from any ond infusion.

Tea as such has no nutritive value, other than perhaps its Riboflavin. At best, because of its caffeine ($H_{10}N_4O_2$), 1·5 to 3 per cent. by weight, it is a mild vous stimulant, which is not followed by any depres-: at the worst when drunk in excess, particularly in er grades, or excessively infused, by reason of its nin, it disturbs the digestive system generally. The f undoubted advantage of its use is that it ensures for st persons the imbibition into the system of fairly large ntities of warm water. Tea as usually served with am or milk and sugar gains the food values of these stances.

Coffee was introduced into England from the Levant in 52 and quickly became the vogue in "coffee-houses." fee is the seed-leaf of Caffea arabica and allied species, evergreen shrub or small tree growing in the moist pics, chiefly, Arabia, British East Africa, Abyssinia, dia, Ceylon, Java, Jamaica and Brazil. The fruit or fee cherry consists of an outer skin, a pulp and a chment skin enclosing two seeds. The berries must t be roasted before use. This is effected by many

types of roasters, commercial and domestic, which roast not simply bake, the berries—a process taking from eight to twelve minutes. In the process caffeine is dissociated from tannin and the sugar is caramelised. As soon as roasted the berries should be quickly cooled and afterwards kept in an air-tight canister. Roasting should be done frequently, even daily, and preferably followed by grinding according to the immediate need. The aroma quickly disappears after grinding and particularly if the ground coffee is not kept enclosed. To make coffee in the home the simplest plan is to use an earthenware jug with a lip for pouring and a lid. The jug should be first warmed and there should be put into it one ounce, if not more, of coffee for every pint of liquor required. Freshly boiling water should be poured in and stirred well with a wooden spoon. Infusion should be allowed to continue in a warm place for about six minutes, and the clear liquid then carefully poured out. Milk when used with coffee should be hot, but not boiling. Unfortunately, in this country at any rate, it would appear that coffee is rarely properly made.

Coffee is often adulterated with chicory, the dried and powdery root of Cichorium intybus (wild endive) which contains no caffeine but more sugar and easily soluble colouring matters, caramel among them. Coffee contains a much less amount of caffeine than tea, but much more fat and tannin. It also acts upon the nervous system which it stimulates, causing wakefulness. It may also have an aperient action by stimulating the muscles of the intestines, hence its place at the end of dinner.

Cocoa was introduced by the Spaniards into Europe from Mexico and Peru, and first came to this country about 1650. It is derived from the roasted seeds of a small evergreen tree, Cacao theobroma. The beans are roasted, then cracked and the several parts, cocoa-nibs, germ and shell separated. The nibs, after blending, are ground to a semi-liquid mass, from which part of the cocoa-butter or fat is pressed, and the cocoa-cake is left to be still further ground down and sifted to form cocoa powder or essence. Eating chocolate is made by adding

ar and cocoa-butter to cocoa-cake. Navy cocoa or e block cocoa is the solidified ground nib and therefore tains much fat, in fact too much so for the ordinary sumer. Soluble cocoa is obtained by treating the cocoa ne stage or other of its manufacture with an alkali, that the natural acidity is neutralised, the colour ened, the aroma and flavour appreciably modified, the fine particles of the cocoa made more buoyant hat they do not settle quickly.

he characteristic nitrogenous ingredient of cocoa is alkaloid theobromine ($C_7H_8N_4O_2$), 1.5 per cent., a stance similar to caffeine in composition and in its on on the nervous system, though much milder. While oa -beans, as naturally occurring, contain much fat, nary cocoa as used at the breakfast table has com- atively little, and its food value is low, even if taken much larger quantities than the usual teaspoonful. as a substance that makes palatable the drinking of water and of hot milk, separately or mixed, that oa is justified as a beverage.

EXPERIMENTS ON BEVERAGES.

Tea.

Experiment 1.

Preliminary Examination.

xamine samples of various types of tea with a strong lens. Note presence or absence of pieces of twig, and rub samples on white r. If the paper is marked it is a probable indication of the nce of used tea leaves coloured with Prussian Blue. Soak of the leaves for a short time in warm water and then unroll of them. Note whether the leaves are whole or broken, as as their shape venation and margin. Sketch a complete leaf

Experiment 2.

To show the presence of tannin in tea.

epare an infusion of tea by boiling some tea leaves in water beaker. Decant some of the liquid into a test-tube and add chloride. A dark blue colouration or precipitate of tannate n indicates the presence of tannin.

Experiment 3.

To show how tannin is extracted from tea.

Make some tea in a beaker and place on a water bath. Remo
10 ccs. of the beverage by means of a pipette at intervals of f
minutes and place the samples in separate test tubes. Add 2
of ferric chloride solution to each and note the colouration
precipitate produced. The depth of colour after the additi
ferric chloride will be an indication of the amount of tannin pres
Does the amount of tannin extracted increase with the length
time the tea is allowed to stand ?

Experiment 4.

To show the danger of drinking tea which has been brewed too lon

Prepare a tannin solution by dissolving some tannic acid in wat
in a test-tube. Add to it a small quantity of isinglass solutio
white of egg, gelatin solution or other protein. Note whether t
protein is coagulated. Repeat with tea which has been brewed f
a long time and compare results. What is the significance of th
experiment ?

Experiment 5.

To illustrate the correct method of making tea.

Label two exactly similar tea-pots A and B. Pour some boili
water into B and leave A at the temperature of the room. After
few minutes empty B and place equal weighed quantities of t
same sample of tea in each. Pour equal quantities of boili
water into each tea-pot and leave them to stand for four minutes.

Take the temperature of the tea in each tea-pot. Pour equ
quantities of the tea from each tea-pot into separate test tub
Note the colour, strength and taste of each.

Add 2 ccs. of ferric chloride to each test-tube and compare t
colouration obtained. Now place the tea-pots on water-baths
15 minutes, pour samples into test-tubes and add ferric chlo
solution to each. Compare the colourations produced.

From your results draw conclusions as to the best methods
making tea.

Coffee.

Experiment 6.

Preliminary Examination.

Examine some raw coffee beans and then roast some in a te
What differences in colour and aroma do you notice ? Plac
small sample of coffee on a filter paper and examine with a str
lens. Is it pure coffee or does it contain chicory. Coffee parti
are dark and rough; chicory particles are smooth and sti
Examine a small quantity under the low power of a microscope

Experiment 7.

To detect the presence of chicory in coffee.

ace a little pure coffee in water in a beaker. Note that it s on the surface and does not discolour the water. Repeat chicory and note that it sinks in the water and also colours the er. Now perform the same experiment with the coffee under The coffee will float on the surface. Any chicory present sink and colour the water.

e addition of chicory to coffee is a common and quite legal tice. Many people consider that the flavour is improved by ddition.

Experiment 8.

To show how coffee differs from chicory.

eigh out 10 gms. of pure coffee in an evaporating basin and 90 ccs. of boiling water. Stir together and allow to stand till In a similar way make an infusion of chicory. Pour 10 ccs. ach infusion into two separate test-tubes and compare their ur, taste and smell. Decant the remainder of the infusions measuring jars and determine their specific gravities by a rometer. That of the coffee will be about 1·009 and that of chicory about 1·024.

the same way prepare an infusion of a mixture of coffee and ory and compare its colour and specific gravity with those of coffee and pure chicory.

Experiment 9.

To test for the presence of tannin in coffee.

ake an infusion of coffee in a beaker and heat it on a water . Remove 10 ccs. of the infusion by means of a pipette and 2 ccs. of ferric chloride solution. Repeat at intervals of five utes. Does coffee contain tannin ?

Cocoa.

Experiment 10.

To identify the food materials present in cocoa.

Weigh out 10 gms. of cocoa in an evaporating basin and add cs. of boiling water. Stir and leave to stand until cold. olourise the infusion by passing it through animal charcoal in a funnel. To samples of the infusion apply tests for proteins, ohydrates and fats.

Experiment 11.

To extract some of the cocoa-butter in cocoa.

ace some cocoa and either in a stoppered conical flask and e well for some time. Filter through muslin and evaporate

the filtrate in an evaporating basin on a water-bath away from flame. When the ether has vapourised a residue of cocoa butter will be found in the basin. Alternatively a little of the ether extract may be poured on filter-paper and after the evaporation of the ether will be found to have a translucent patch due to the cocoa butter.

If a Soxhlet extraction apparatus is available this experiment can be performed quantitatively.

Experiment 12.

To test for the presence of tannin in cocoa.

Make an infusion of 10 gms. of cocoa in 90 ccs. of boiling water. Decolourise by passing through animal charcoal and to about 10 ccs. of the liquid add 2 ccs. of ferric chloride solution. Does cocoa contain tannin ?

CHAPTER XXIV.

SPICES AND CONDIMENTS.

ces, condiments and similar flavouring materials, d in great variety in the preparation and serving of d though not for nourishment—providing as they do e that is a source of energy or of building material—e yet definite uses in giving relish to food, in arousing petite, and in promoting the secretion of saliva and tric juice and so positively aiding digestion. Even inary healthy appetites appreciate the presence of an propriate pungency by way of condiments in the various ds before them; all the more so jaded appetites where palate or digestion is enfeebled by either sickness or se. Particular flavourings are associated with various ats: mustard or horse-radish with roast beef; mint-ce with lamb; caper-sauce with mutton; sage and ons with pork or fowl; red currant jelly with hare; on juice with fillets of fish or oysters, and vinegar h oysters and molluscs generally, or crabs and other staceans. Pepper and salt have a universal application the kitchen and at the table. Sauces and chutneys real assistants in the eating of cold and insipid meats. n mediæval times, and even later until what may be ed the agricultural revolution, fresh meat after Sep-ber was rare, for then most of the herds had been ghtered and their carcasses salted down to serve until l on into the New Year. In comparison with our sent day fresh or refrigerated meat produced on far r pastures than were ever available in the old times, at was then at best coarse, and at worst tough and palatable, if not repulsive because of decay. The use spices and condiments was necessary to hide the leasant taste and flavour of imperfectly preserved half-rotten flesh. The demands of Western Europe these assistants to digestion resulted in a very consider-e spice industry in the Orient and Levant, and on its nsport and commerce the Venetians largely built up

their empire of the seas. It is sometimes stated that its serious hindrance to the flow of spices into Europe overland and by sea, from the East resulting upon the capture of Constantinople by the Ottoman Turks in 145 was a primary factor in turning the attention of western navigators to the possibility of other routes to the spice islands of the East by way either of the southern route by the rounding of Africa which was discovered by Vasco da Gama in 1497, or westward across the Atlantic, found by Columbus in 1492. Spices are less used to-day in this country, apart from pepper, mustard and prepared sauces, than in Asiatic countries, in America, or on the Continent. Where spiced breads and sweets, and various kinds of sausage are consumed in quantity, as in Germany, the consumption of spices of all sorts is heavy.

Pepper. Pepper is the seed of Piper nigrum, a perennial creeper or vine, with much the same habit of growth as our black bryony. The pepper vine is cultivated or grows wild over most of tropical Asia, chiefly in the East Indian peninsulas and archipelagoes. The fruits are one seeded berries growing closely packed together, and when fully grown are green but on the point of turning red. At this stage they are plucked for the production of black pepper; for the production of white pepper they are allowed to ripen fully and are gathered when fully red. Black pepper with the maximum pungency and aroma comes to this country largely from the Dutch East Indies (47,341 metric tons in 1935-36): white pepper comes largely from the Isle of Banka in Dutch East Indies (13,000-14,000 metric tons annually). Other supplies are shipped from Singapore and Sarawak.

The bulk of domestic pepper is in the form of ground pepper: for table uses white pepper is usually preferred on the score of appearance when sprinkled, but in the kitchen black pepper has the advantage of aroma and pungency. The colour of ground white pepper varies according to the type or quality of the original peppercorns and to the processes of manufacture—such as screening from pieces of husk, bleaching, tinting with turmeric, or admixture with adulterants. White pepper should have

ream or greyish tint according to grade or quality. ere flavour in food is appreciated it is better to grind required black or white peppercorns in a small table l: the difference between such freshly made pepper l long stored dry processed pepper is marked.

Pepper owes its pungency and aroma to an essential and an alkaloid (piperine) $C_{17}H_{19}NO_3$, to the extent ome 8 or 9 per cent., especially in black pepper from ch it can be readily extracted by warming with milk ime for 15 minutes, then evaporating to dryness and ing up with ether. The action of piperine is to nulate the flow of saliva and the gastric juices, and in ess to promote perspiration, hence its use in the tment of fevers. Pepper is also appreciably rich in min C.

Blue Poppy or Maw Seed is bluish grey in colour and is ensively used on the Continent and in the Jewish rters of London to decorate bread and rolls, and when shed, as a layering in yeast cakes.

sicum and Chillies. These are the fruit pods of annual plants related to the ato, viz., Capsicum minimum and C. frutescens pectively. When grown in the tropics they are very gent but allied species grown in Europe either lack eat " or are mild. Both capsicum and chillies appear e indigenous to Central and South America and the st Indies but are now grown widely in the tropics of n Old and New Worlds.

he large pods (1½ to 4 inches in length) are described apsicum and the smaller pods as chillies. Capsicums exported from India, China, Japan, Central America, t and West Indies and Africa, and chillies from ish East Africa, Portuguese West Africa, British West ca and Java.

ayenne Pepper is prepared by grinding capsicums and lies. Nepaul Pepper from the orange yellow Nepaul sicums has much more aroma than the ordinary hot per: it is highly esteemed but is expensive. The e pungent capsicums and chillies are largely used in

the manufacture of medicated cotton wool and heat giving liniments for the relief of muscular pains and congestion. They are also used in pickles, chutneys, curries and sauces. The pungency of red pepper is due to violently active poisonous substances, which, however, in very small quantities are useful stimulants and carminatives.

Paprika or Hungarian pepper of the higher grades is a sweet red pepper with little or no pungency prepared from a capsicum (C. annuum) grown in Hungary, Yugo-Slavia, Spain, Algeria and Chile. The best paprika is grown in Hungary; lower grades are hot. Paprika pepper is used to garnish dishes, to colour and flavour gravies, stews and hashes, and generally for its colouring and preservative qualities by packers of meat products. Paprika was the first considerable natural source of vitamin C.

Caraway Seeds are the fruits of the caraway (Carum carui) belonging to the Umbelliferæ, to which family also belong fennel, carrot, parsley, angelica, celery and dill. Seeds and leaves of this family are usually aromatic, containing oils which stimulate the digestive tract and are hence used in medicines as carminatives, such as dill water. Caraways have long been cultivated in Holland as well as generally in other European countries. Seeds of good quality have a bright colour, are very aromatic and yield from 4 to 6½ per cent. of an essential oil. In addition to their use in medicine and for the flavouring of cakes, bread, baked fruits, roast pippins and, in Germany, cheese and soups, they are used in perfumery, as in Brown Windsor soap and for flavouring cordials and liqueurs (Kummel).

Celery Seed is used as a flavouring ingredient in celery salt and home remedies for rheumatism.

Cardamoms are small dark brown or nearly black seeds contained in the capsule of Elettaria cardomomum, a plant allied to ginger, growing in Ceylon, India (Mysore and Malabar), Java and Jamaica. The seeds, rich in volatile oil, are used as carminatives and to mask the

e of unpleasant drugs. They are also used as an edient of flavourings for soups, sauces and cordials soft drinks."

assia is the bark of aromatic laurels belonging to the e genus as that which yields the true cinnamon. erent varieties of cassia of several tropical countries e from different species of cinnamon. Most of the ia imported into this country comes mainly from China angsi, Kwantung and Hainan) and is exported from g Kong. Cassia bark varies in thickness and is h coarser and more woody than cinnamon. It is also inguished from cinnamon by breaking with a short ture, in not being rolled into quills, and in its much ker colour. The best cassia (Saigon) has a flavour aroma suggesting those of true cinnamon but it does possess its medicinal qualities. Cassia is valued for flavour and relative cheapness, and is largely used in und mixed spices.

innamon is a product of Cinnamomun zeylanicum, an matic laurel which grows most abundantly, wild and ivated, in Ceylon. The tree is coppiced and made to d continuously, even for 100 years, willowy shoots e six to ten feet long. The shoots when two years are cut, usually in May, and the bark is slit down on h sides and left for a few hours to ferment and dry. quills so formed are graded and bundled. Broken ments of bark and quills from chips are ground and illed to produce cinnamon bark oil. Another oil is illed from the leaves, and containing much eugenol is d in the production of artificial vanilla.

innamon is one of the most pleasant flavouring spices is admirable for flavouring cakes and puddings. It also uses in medicine as an astringent in cases of rhœa when taken in the form of dry powder mixed icing sugar. It is also used as an internal disinfec- and is often prescribed as a relief, if not a cure, for uenza.

loves, consist of the dried and unopened flower buds Eugenia caryophyllata, a tropical evergreen found in

the Moluccas. For many years the Dutch held a monopoly of the clove trade but more recently Zanzibar and Pemba have been the principal sources of the world's supply. Other supplies come from Madagascar, Ceylon and the Seychelles Islands. The cloves produced in Amboyna in Dutch East Indies are the fullest flavoured of all, containing some 20 per cent. volatile oil as compared with the 17 per cent. of Zanzibar cloves. The oil consists essentially of eugenol. Clove oil has many uses in medicine and in perfumery as well as in domestic cookery. It is the source from which artificial vanilla is manufactured.

Coriander Seed is obtained from an umbelliferous plant, Coriandrum sativum, a native of the Mediterranean countries and the Caucasus. It has long been extensively cultivated in North India, French Morocco and Russia and is found semi-wild in eastern counties of England as an escape from an old cultivation. The seed is nearly globular, about the size of a sweet pea seed; when fresh it smells disagreeably but when ripe is very fragrant with a very pleasant warm pungent taste. It is an important ingredient of curry powder and of mixed spice, and is used as a flavouring in fancy breads, confectionery, medicine, gin, and some liqueurs.

Curry Powder is a condiment of very variable composition according to the fancy of the maker. The spices most generally used in its manufacture are coriander, turmeric, cumin, ginger, pepper, chillies and cardamom seeds. Some curry powders also contain fenugreek, pimento and nutmeg.

Fenugreek consists of the small yellow brown angular seeds of a plant of the clover family which is cultivated principally in Morocco and Tunis. The seeds are used considerably in veterinary practice and in poultry spice as a means of keeping animals in condition. They are rich in phosphates, iron and lecithin, and have long been used in medicine in the East. Fenugreek is an ingredient of curry powder to which it imparts colour, aroma and flavour. Its aroma is due in part to its coumarin, a natural perfume that of new-mown hay found mor

undantly in tonka bean and sparingly in sweet woodruff
d sweet vernal grass.

Ginger is the dried root or rhizome of Zingiber officinale.
native of India and China. The principal sources are
dia, Jamaica and Sierra Leone, although recently
oplies have come in from Nigeria and Ceylon. The
est ginger is grown in Jamaica; it has the best aroma
d is well prepared for the market. The normal colour
peeled ginger is yellowish buff, but it is also sold with a
w-white coating of lime, although the extra processing
newhat impairs the quality. The medium and lower
ades of ginger from Africa are largely used for grinding
for making ginger beer and essence, and as an ingredient
cattle and poultry spice. High grade ginger contains
m 1·5 to 3 per cent. of a volatile oil and about 3 per
nt. of a fixed oil—hence its use for flavouring in the
chen and as a stomachic in medicine.

Mustard is produced by the grinding of the endosperm
the black mustard seed, Sinapis nigra, and white
ustard seed, Sinapis alba; the former actually more
own than black and the latter yellow. The best white
d is grown in this country, chiefly in East Anglia.
hite mustard seed is some three times the size of the
ck seed but has less pungency and aroma. Both white
d black mustard seeds contain glucosides and their
ompanying enzyme, myrosin. The myrosin of the
ite mustard acts on its glucoside and produces a
phur compound of very pungent taste but devoid of
oma; the glucoside of the black mustard, potassium
ronate ($C_{10}H_{18}NS_2O_{10}K$), undergoes a similar fermenta-
n and yields in addition to glucose and potassium acid
phate, allyl iso-thiocyanate ($C_3H_5N : CS$) which is a
ourless, pungent smelling and tasting oil—mustard oil.
is oil is very powerful in its action; when dropped on
skin it rapidly produces blisters and except in great
ution its odour is intolerable.

Mustard flour is usually a mixture of black and white
d flour obtaining its pungency of taste and aroma from
black seed, and its "body" and enzymic properties
inly from the white seed. When mustard flour is used

as a condiment it is mixed with cold water, vinegar or o in order to bring the myrosin and the glucosides int action : the heat of hot water or milk kills the myrosi so that mustard made with either lacks flavour. Th first grade of mustard is known as G.D.S.F. (genuin double superfine) and is a blend of superfine white an black flours, the commoner grade known as D.S.F mustard compound (double superfine flour) consists o superfine flour of white and black seed mixed with proportion of dried wheaten flour. Some more or les worthless mustard includes seeds of brassica, turmeric an cornflour. Mustard has various uses : as a table condi ment where it gives pungency to cold meat and assists th appetite ; medicinally as a speedy emetic and in the form of mustard plasters or bath mustard—in these case mainly derived from black seed.

Nutmegs and Mace. The nutmeg tree, Myristica fragrans, i grown most extensively in the East Indies and in Grenada and Trinidad in the Wes Indies. The fruit resembles an apricot and when ripe it outer covering or pericarp splits and reveals a red aril the mace, closely enmeshing the shell in which the nutme lies as kernel. The mace is stripped off and flattened b hand and laid out to dry, changing colour to a yellowis brown. The nutmegs in the shells when sufficiently dried over slow fires and in the sun are carefully release by the cracking open of the shells, bruising being avoided Good nutmegs are rich in oil, which is evident when the are stabbed with a needle. When a nutmeg is grated th solid end should be used first so leaving the opposit cavernous end as waste.

Mace is an aril or fibrous network surrounding th nutmeg seed as an outgrowth of the seed coat. Th finest flavoured mace comes from Penang and Singapor but most of our supplies come from Grenada. Groun mace is used in the kitchen for flavouring ; it should b kept in an air-tight container for the essential oil is ver volatile.

Pimento or Allspice is the berry of a West India evergreen myrtle (Eugenia pimenta), allied to the clov

berry is nearly globular in shape, of rich brown our, light and brittle, and contains two small bean-ped seeds. The smaller berries are usually the more ngent and fuller flavoured. Volatile oil resides in the k of the berry and may amount to 2·5 per cent. The ne allspice is derived from the supposed resemblance a mixture of cinnamon, nutmeg and clove.

Pimento is much used in pickling, especially of walnuts, l in stews, and when ground, in flavouring meats such Strasbourg beef, sausage and potted meats. It enters gely into the composition of mixed pudding spice.

eet Herbs. The sweet herbs used in the kitchen are the dried parts of plants—leaves, roots, its and seeds—commonly cultivated in the herb den, which because of the flavour and fragrance due volatile oils peculiar to the individual species are used giving characteristic flavours to soups, stews, salads l so on. Most of the sweet herbs are native to the sunny soils of the Mediterranean countries but were roduced into this country at various times : first by Romans, but more especially later by the various ers of monks. The use of sweet herbs for culinary poses was well developed throughout the Middle Ages adjuncts to the more pungent spices from the East, l much more so than to-day.

By far the great majority of the thirty odd plants tivated as sweet herbs belong to two orders of the biatæ and the Umbelliferæ. Examples of the former balm, basil, sage, marjoram, rosemary, mint and thyme. l of the latter parsley, dill, fennel, angelica, aniseed, away. Sweet herbs belonging to other orders are , borage, sweet bay and chives. The commonest bs in present-day use are parsley, sage, thyme and t.

Parsley is grown largely for its leaves, to serve as a nishing and a flavouring, whether fresh or dried and dered. Oil is extracted from the fresh fruits.

The leaves of sage are used as flavouring and seasoning oups, in stuffing with onions for ducks, geese and pork,

as a substitute for tea in cooling drinks, as an ingredient in herb beer and for perfumery in the scenting of soaps. Its essential oil contains pinene ($C_{10}H_{16}$).

Garden thyme is a cultivated form of wild thyme of the Mediterranean coast where it has long been associated with the production of the finest flavoured honey. The oils distilled from various species of thyme contain pinene and borneol ($C_{10}H_{17}OH$) and are used for the preparation of scented soaps.

Mint occurs as three species, the spearmint, peppermint and pennyroyal; the first is that ordinarily used in the kitchen, the other two are medicinal herbs. Garden mint was introduced into this country by the Romans. It is commonly eaten with lamb for it makes the meat more digestible by stimulating the digestive glands. The oil distilled from the leaves is extensively used to flavour toothpaste and chewing gums; it contains menthone ($C_{10}H_{18}O$) and menthol ($C_{10}H_{19}OH$).

Common Salt consists essentially of almost pure sodium chloride (NaCl), derived in this country from natural brine springs or wells, or from deposits of rock salt, but in warm countries still mainly by the evaporation of sea water. Even in this country during the Middle Ages, salt was largely obtained by the evaporation of sea-water, run into shallow ponds or salterns; traces of these may still be found in the neighbourhoods of Portsmouth, Lymington and Poole Harbour. From the centres of this sea-salt industry and from the naturally occurring brine springs at Droitwich and Northwich, ancient track-ways, the salt ways, radiated throughout the country over which a considerable traffic was long carried. In those days salt had a more extensive domestic use than to-day as a preservative of meat, fowl and fish upon which the vast majority of the people depended in the winter and spring months for their flesh food.

In Cheshire, the most considerable area of salt manufacture in this country, brine, a 25 per cent. solution of salt in water, is pumped up out of bore holes sunk

the marls of the New Red Sandstone and then evapored in flat iron pans by artificial heat with the help of educed pressure. According to the rate of evaporation ifferently sized crystals of salt separate out; large rystals of fishery and bay salts when the evaporation is ow, and small crystals as fine or table salts when it is pid. For table use salt must be dry and reasonably ee from impurities, such as the poisonous salts of barium. yet contains small quantities of hygroscopic impurities hich, absorbing moisture from the atmosphere, cause ne salt to cake or become damp. In free running table lt this is prevented by the addition during processing of nall traces of fine sodium phosphate or carbonate, or ce powder.

Besides its use at the table for adding flavour to underasoned food, salt has many uses in the kitchen. It is sed for preserving meat, being rubbed into fresh meat as rystals or allowed to soak into it as brine. Salt here cts in two different ways; as antiseptic, killing bacterial nd fungus germs, and by reason of its water-absorptive owers related to its osmotic pressure, as a dehydrater of ells and tissues. In very weak solution—as about 3 per ent.—the osmotic pressure of salt tends to stop the iffusion and so the loss of the natural salts of fish or eshly cut meat when being simmered in water; the avour of fish is particularly improved by the addition of lt. Potatoes and vegetables generally, when boiled ithout salt are flavourless, because of the loss of their atural salts, a fault which cannot be corrected afterards at the table by the addition of salt. With good ooking there should be little or no need to add salt to od at the table. Salt plays an important role in the aking of bread, not only as a flavouring but even more a stabiliser of the gluten (see page 215).

Some brands of table salt contain small proportions of ch ingredients as sodium or potassium iodide in order to pply to the system iodine, which is needed for the proper nctioning of the thyroid gland, particularly where the rinking water of the district is deficient in this element ee page 123). Celery salt is a mixture of ordinary salt th celery oil.

Vinegar. Vinegar, or "sour wine," is formed when light alcoholic beverages, such as weak wines, cider and ale, are left exposed to the atmosphere, the alcohol being then oxidised by Bacterium aceti to acetic acid, the characteristic constituent of all vinegars, however prepared. $C_2H_5.OH + O_2 = CH_3.COOH + H_2O$.

Vinegars may be easily divided into two main classes, according as the acetic acid is produced by the fermentation carried through by B. aceti and allied micro-organisms of alcohol derived in its turn by the fermentation of saccharine solutions, or whether, as in artificial vinegars, acetic acid obtained from ordinary industrial sources is simply diluted with water to the required strength and then coloured and flavoured to taste. Fermented or brewed vinegar is produced in England and Wales to an amount lying between 10 and 20 million gallons yearly; the output of artificial vinegar it is impossible to measure, but in all probability far exceeds this amount.

Fermented Vinegars. These are dependent upon B. aceti, which is always present in the atmosphere and finds food and a suitable medium for its activity in dilute alcoholic liquors of various origins. The bacterium cannot, however, act on strong alcoholic beverages such as port, sherry or whisky. The colour, flavour and aroma of the various types of fermented vinegar depend largely upon the nature of the original alcoholic liquor. In England, brewed vinegar is almost entirely derived from various kinds of grain and sugars—almost anything which can be made to yield a saccharine solution being used. Exceptionally, it is brewed entirely from barley malt, but more generally from mixtures of malted and unmalted barley which may be replaced by other grains such as maize or rice. In France, vinegar is made from inferior white and red wines. In the United States of America, it is now very largely made from apple cider.

The process of manufacture of malt vinegar falls into four stages: 1. **Mashing,** in which the starch of the grain is converted by diastase, etc., into fermentable sugars, such as glucose. 2. **Vinous Fermentation,** in which yeast converts the sugar into alcohol. 3. **Acetous Fermentation,** in which the alcoholic liquor is converted by Bacterium

eti with the absorption of oxygen into acetic acid. 4. **Clarification,** which the originally turbid vinegar is rendered clear and fit for nsumption. The distinctive stage of acetification is carried out large vessels in the form of a truncated cone the upper portion which is filled with birch twigs, beech shavings or basket work on which the bacterium grows, and the lower portion contains e "wash" from alcoholic fermentations to be acetified. The ash is continuously pumped up to the top of the vessels and rayed upon the mass of twigs, etc., impregnated with the micro-ganism, when, in the presence of sufficient air, it is slowly trans-rmed into vinegar. Acetification takes a week or fortnight to mplete. It is usually stopped before all the alcohol is converted as to allow the subsequent slow formation of esters, which are olatile compounds of the acid with alcohols, and give flavour nd aroma to the refined vinegar.

A good vinegar should not show the growth of mould but ordinary nd weak vinegars are very liable to this. Various preventatives are sed to stop mould formation, including "fortification" by the ddition of the requisite quantity of acetic acid or even sulphuric cid. Calcium bisulphite is the preservative now chiefly used. inegar as it leaves the clarifying stage contains from 6 to 7 per ent. of acetic acid. This stock vinegar is diluted with water to roduce various grades of vinegar. These are designated in the rade by numbers: such as 24, containing 6·2 per cent. acetic acid, 0 with 5·1 per cent., 18 with 4·6 per cent. and so on; the numbers ere originally intended to indicate the number of grains of sodium arbonate which would neutralise an ounce of the vinegar. Weaker inegars with about 3·5 per cent. acetic acid are those most commonly tailed.

Distilled Vinegar.—This is prepared by distilling malt vinegar, either pure or fortified, and comes over as clear colourless liquid, consisting practically of acetic cid and water, but with small traces of the aromatic olatile bodies. It is more widely used in Scotland than n England, and is also sold as "crystal vinegar" and white wine" vinegar.

Wine Vinegar.—This has a limited use among the etter class caterers and pickle makers. The best wine inegar is made from white wine and is imported from rleans, and contains from 5 to 5·6 per cent. of acetic cid. Small quantities of wine vinegar are made in his country from wine which has gone sour, or from wine" made here from raisins or grape juice.

Imitation wine vinegars are largely sold as wine vinegars ut are simply made by diluting spirit vinegar until it

contains about 5 per cent. of acetic acid and then adding suitable colouring matters. Such imitation wine vinegars can be sold cheaply at 6d. or even less per gallon.

Spirit Vinegar.—This is made in Germany by the acetous fermentation of dilute distilled alcohol—chiefly potato spirit. Traces of higher alcohols give it a distinct aroma and, when diluted and mixed with wine lees, forms a very palatable imitation of true wine vinegar.

Special or Fancy Vinegars such as Raspberry and Tarragona vinegars are prepared by treating the appropriate fruit or herb, or flavouring essences with malt vinegar. These vinegars are usually sold at prices far in excess of the value of the contents.

Artificial Vinegars. The simplest artificial vinegar consists of industrial acetic acid well diluted with water and coloured with a little caramel. Such a vinegar has a harshness and pungency lacking in any variety of fermented acetic acid. The acetic acid used is obtained from wood by destructive distillation, and is separated from other products of distillation as the calcium salt, from which it is liberated pure by distillation with sulphuric acid. Recently acetic acid of high purity has been prepared from alcohol by acetous fermentation in the usual way: the dilute acid so formed being first neutralised by treatment with calc-spar and then liberated afresh by distillation with sulphuric acid. This latter type of acetic acid has not the harsh raw flavour of wood acid when diluted.

Large quantities of artificial vinegar are retailed in small bottles among the poorer classes of the population, mainly of industrial districts, certainly at low prices to the consumers but with excessive profits to the makers and distributors. There is, however, little difference in the primary costs of brewed and artificial vinegars of the strength of 5 per cent.: a matter of 5d. a gallon as against 3d. a gallon. These are both retailed usually at about 1½d. or 2d. per pint. Vinegars of either type should contain at least four parts by weight of acetic acid in a hundred parts.

EXPERIMENTS ON VINEGAR.

Experiment 1.

To prepare a sample of vinegar.

Leave a sample of claret diluted with an equal volume of water r a sample of beer (full strength) exposed to the air for several ays or inoculate the samples with acetic acid bacteria (Bacterium eti) from old vinegar and keep at a temperature of about 38 C. r several days. At the end of this time examine the appearance, nell and taste of the sample. Test with litmus paper and then dd a few drops of ethyl alcohol. In the presence of acetic acid a naracteristic fruity smell of ethyl acetate will be noticeable.

Experiment 2.

Preliminary tests to identify types of vinegar.

Quickly evaporate samples of vinegar in an evaporating basin nd note the smell in each case. The different type of vinegar ve off differing smells according to their sources, e.g. :

Malt vinegar gives a smell of malt.
Cider vinegar gives a smell of apples.
Wine vinegar gives a smell of grapes.
Distilled vinegar gives a smell of burnt sugar.
Artificial vinegar gives no identifiable smell.

Experiment 3.

determine the percentage of total solids in a sample of vinegar.

First shake the sample well and then transfer by means of a pette 10 ccs. into a previously weighed dish. Obtain the weight vinegar either by weighing or from the specific gravity. Evapor- e on a water-bath to a syrupy consistency and finally dry in a eam oven. Cool and weigh. If any difficulty is experienced in moving the last traces of acetic acid by evaporation the residue ay be treated with a little alcohol and again evaporated to dryness d weighed. The percentage of total solids can easily be determined om the weighings obtained.

Malt vinegar should contain about 3 per cent. of total solids.

Experiment 4.

To examine the residue left after evaporation of vinegar.

(*a*) **Phosphates.**

Carefully ignite the residue from the previous experiment. Add a w drops of water to the ash left and boil. Test the solution with d litmus paper and note if an alkaline reaction is obtained. If e solution is alkaline the vinegar is free from mineral acids. (Why ght mineral acid be present ?)

Next acidify the solution of the ash with a few drops of nitric acid and filter. To the filtrate add a considerable excess of ammonium molybdate solution and warm to precipitate the phosphate. A normal malt vinegar usually contains 0·05 to 0·1 per cent. of phosphoric acid.

(*b*) **Tartrates.**

In the case of a wine vinegar another portion of the vinegar should be evaporated to dryness. Treat the dry residue with absolute alcohol and heat on a water-bath for a short time until no more of the solid matter will dissolve. Carefully pour off the alcoholic solution and dissolve the residue in the smallest quantity of hot water. Add a drop of acetic acid, transfer to a watch glass and precipitate the acid potassium tartrate by gently stirring with a glass rod.

(*c*) **Tartaric Acid.**

Tartaric acid is occasionally added to vinegar as an adulterant. In such cases the residue obtained on evaporation is viscous and acid to litmus. On the addition of alcohol to the residue the free tartaric acid will dissolve. Evaporate the alcoholic extract almost to dryness on a water-bath, add a few drops of a concentrated solution of potassium chloride and transfer to a watch glass. Add a drop of acetic acid and stir gently with a glass rod. A fine white precipitate of acid potassium tartrate (cream of tartar) will be formed as in the previous experiment above.

Experiment 5.

To determine the total acidity of a sample of Vinegar.

The acidity of vinegar is determined by direct titration with standard alkali using phenolphthalein as indicator. The result is returned as acetic acid. By suitably diluting the vinegar before titration any interference due to the sample being highly coloured can be reduced.

Dilute 10 ccs. of the sample of vinegar to 100 ccs. in a graduated flask and titrate portions of 25 ccs. with N 10 caustic soda using phenolphthalein as indicator. Calculate the acidity as grams of acetic acid in 100 ccs. of vinegar.

The strength or acidity of vinegar is sometimes expressed by a number; 18, 20, 22 and 24 are the strengths most usually used. These figures refer to the number of grains of dry sodium carbonate required to neutralise 1 oz. of vinegar.

Strengths expressed in this way may be converted to percentage and vice versa as follows:—

The "number" of the vinegar multiplied by 0·259 gives the percentage of acetic acid and conversely the percentage of acetic acid divided by 0·259 gives the "number."

Experiment 6.

To test for the presence of alcohol in vinegar.

Owing to its method of preparation vinegar is liable to contain all quantities of alcohol. To test for its presence a sample of the negar should be distilled and the distillate neutralised with ustic soda solution. Warm the solution with a solution of iodine potassium iodide solution. Add caustic soda solution until the uid is almost colourless. On standing a yellow precipitate of doform with a characteristic smell is obtained if alcohol is present.

Experiment 7.

To test for the presence of sulphuric acid in vinegar.

The test for sulphuric acid is to add a solution of barium chloride; e precipitate is insoluble in hydrochloric acid.

CHAPTER XXV.

FLAVOURING AND COLOURING MATERIALS.

Flavouring Agents.

The chief substances used as flavouring agents for confectionery purposes are essential oils, essences, liqueurs and fruit juices.

Essential Oils. Essential or volatile oils are liquids which impart a characteristic odour to the flower, fruit or other part of plants containing them. They must be distinguished from paraffin or rock oils on the one hand and fixed or fatty oils on the other. The essential oils are only occasionally single substances: usually they are composed of several chemical substances, e.g., terpenes ($C_{10}H_{16}$), camphor compounds as well as aromatic and aliphatic alcohols, phenols, aldehydes, ketones, acids and esters. Generally, essential oils are colourless liquids when pure and with strong odours and tastes. They are volatile without decomposition and can be distilled unchanged. They are practically insoluble in water but easily soluble in alcohol. On keeping they are liable to become darker in colour and thick in consistency. It is for this reason that all flavouring materials should be kept in well-stoppered bottles. This prevents loss of material by evaporation and loss of flavour by atmospheric oxidation.

Several methods are used for extracting the essential oils from plants. Among the more important may be mentioned distillation, pressing, solvents, maceration and enfleurage. In the distillation process the material containing the essential oil is placed in a still with water and heated to boiling. The essential oil is distilled off along with steam and collected through a condenser. The distillate is at first milky in appearance but on standing separates out into two layers with the oil usually at the top. The water is drawn off and returned to the still or the distillation may be carried out by a continuous

rocess. In the pressing method of extraction such as is sed for oranges and lemons the oils are obtained by ydraulic presses or by hand. The usual solvent method by means of alcohol. After extraction the solvent is stilled from the oil and recovered for further use. The aceration and enfleurage methods are used in the case oils which are injured by a strong heat. A perfectly ure neutral fat is melted and the flowers or leaves stirred to it. The essential oil is taken up by the fat and terwards extracted from it by alcohol. Such solutions alcohol are frequently used in perfumery. The residual t still contains some of the essential oil and is made use in the preparation of pomades.

Apart from their use as flavouring materials essential oils so find application in perfumery, medicine and pharmacy. he most important essential oils used in confectionery e those derived from bitter almonds, vanilla beans, anges, lemons, angelica and peppermint. Among those ed for other purposes may be mentioned turpentine, mphor, thymol, menthol, and oils of eucalyptus, winter-een and lavender.

sential Oil of tter Almonds.

This oil is obtained from the kernels of bitter almonds, (Amygdalus communis) as well as of apricots, peaches and ctarines. All these kernels contain also a fixed fatty which must first be removed. This is done by grinding e kernels to meal and then subjecting the meal to powerful draulic pressure. The fixed oil expressed in this way a typical liquid fat resembling olive oil in appearance d properties. The press-cake is then ground to powder d boiling water added to it. This is allowed to cool, sh ground almond press-cake mixed in and allowed stand for twelve hours. During this steeping the coside, amygdalin, present in the kernels is hydrolysed the enzyme, emulsin, into benzaldehyde, glucose and ssic acid.

$$C_{20}H_{27}NO_{11} + 2H_2O = C_6H_5CHO + 2C_6H_{12}O_6 + HCN$$

Amygdalin Water. Benzaldehyde Glucose Prussic acid

When hydrolysis is complete the mixture is distilled in partial vacuum, and benzaldehyde and prussic acid are

thus separated from glucose and the residue. To remove the poisonous prussic acid the distillate is treated with ferrous sulphate and milk of lime. The ferro cyanide of calcium thus formed is insoluble and non-poisonous and is removed by filtration. Finally the filtrate is steam-distilled to obtain the oil of bitter almonds.

Artificial oil of bitter almonds is prepared from the coal-tar hydrocarbon, toluene, $C_6H_5.CH_3$, by chlorinating it to benzal chloride $C_6H_5CHCl_2$ and then heating it with milk of lime under pressure in an iron vessel.

$$C_6H_5CHCl_2 + H_2O + CaO = C_6H_5CHO + CaCl_2 + H_2O$$

This artificial oil of bitter almonds or benzaldehyde is also used in the preparation of dyes. Nitrobenzene, $C_6H_5NO_2$, prepared by nitration of benzene with concentrated nitric and sulphuric acids, is used as a substitute for almond oil for scenting soap under the name of "oil of mirbane." It is highly poisonous and must not be used as a flavouring agent.

The essential oil of bitter almonds is a volatile liquid with a distinctive odour and can be readily distilled without decomposition. It is, however, very easily oxidised on exposure to air, and the necessity for keeping essential oil in tightly stoppered bottles is particularly applicable in this case, since the benzoic acid formed on oxidation is a crystalline substance devoid of flavouring properties. The natural oil has a superior aroma and a less harsh flavour than the artificial product, owing to the presence in the former of small traces of substances other than benzaldehyde derived from the almonds.

Finally it should be noted that it is only the bitter almond which yields an essential oil. Sweet almonds contain the same fixed oil as bitter almonds but no essential oil.

Vanilla. The essential constituent of vanilla is vanillin a very widely used flavouring agent. Vanilla pods from which the vanillin is extracted are the fruits of a tropical climbing orchid which flourishes in the French tropical colonies, Mexico, West Indies and South America. The vanilla beans, which are greenish yellow in colour

odourless when gathered before they are fully ripe, subjected to a fermentation or curing process. A cific enzyme brings out the characteristic odour by development of vanillin, which appears as a white orescence of needle-shaped crystals on the outside of beans. The beans are sun-dried and packed for ort. In this form they are about 8 inches long, about uarter of an inch thick in the middle, and have a dark inkled surface. The vanillin content of the pods is newhere in the region of 2 per cent, but the proportion vanillin is not necessarily a criterion of quality since fine aroma of vanilla is also due to a combination of ns, resins and oils in the form of a balsam.

The pods may be crushed to a powder and mixed with ne times their weight of sugar and used in this dry form sprinkle over cakes, etc., or the pods may be broken o small pieces and steeped for several months in ohol to which a little sugar and glycerine are added, forming " essence of vanilla."

Vanillin can be prepared artificially by oxidation of genol with alkaline permanganate of potash. Eugenol a phenolic compound found naturally in cloves, pimento d cinnamon.

$$C_6H_3OH.OCH_3.C_3H_5 \longrightarrow C_6H_3OH.OCH_3.CHO$$

Eugenol. Vanillin.

The vanillin thus prepared is dissolved in alcohol to e artificial vanilla essence, which is then coloured with amel. The artificial essence never attains the delicacy flavour of the natural product, any more than does ificial oil of bitter almonds, and for the same reason.

sential Oils of anges & Lemons.

The essential oils of these two citrus fruits occur in small glands in the rinds from which they are racted by pressure. On the larger scale hydraulic screw presses are used but the finest quality oils are duced by hand. One hand-method is the sponge and l process in which the peel is cut into halves and the expressed by turning them inside out and then wiping the oil by a sponge and squeezing the sponge in a

bowl. In another hand-process the rind is rotated rapidly in a round metal bowl studded with sharp spikes which burst the glands containing the oil. The extracted oil collects in a receptacle at the bottom of the bowl.

The chief regions in which these oils are produced are Syracuse, Palermo and Messina in Sicily, while California is a more recent source of supply. The characteristic ingredients of these oils, limonene ($C_{10}H_{16}$) and citral ($C_{10}H_{16}O$) are present to the extent of about 4-5 per cent. The remaining ingredients are chiefly terpenes. The oils are pale yellow in colour with characteristic aromas and bitter aromatic tastes. The extracts or essences are prepared by dissolving the oils in alcohol.

Essential Oil of Angelica. As previously mentioned on page 357, angelica is a perennial umbelliferous plant cultivated for its aromatic stems and candied in a similar way to candied peels. The essential oil in these stems has a pale greenish yellow colour and a pleasant aromatic smell.

Essential Oil of Peppermint. This oil is obtained by distillation of the herb, (Mentha piperita). It is a colourless or greenish yellow liquid with a strong pungent taste and smell. Its characteristic ingredient is menthol, the remainder being a mixture of several terpenes.

Although they are not used as flavouring materials, we may briefly consider some of the other important essential oils at this point.

Oil of Turpentine or Spirits of Turpentine. This very widely used oil is obtained from coniferous trees, particularly pines. A cavity is cut near the root of the tree and shallow cuts made in the bark leading down to a box. An oleo-resin flows from the cuts and is collected in the box from which it is withdrawn at intervals. The sticky viscid liquid is distilled with steam, which extracts the volatile oil of turpentine and leaves behind a residue of resin or rosin. This oil is further purified by washing with caustic soda solution to remove rosin acids and then re-distilled to

tain "rectified spirits of turpentine." Such turpentine a colourless, mobile refractive liquid which will not ssolve in water, but itself possesses great solvent powers. lphur, phosphorus, wax and resins easily dissolve in rpentine. It is used as a solvent in the preparation of ints and varnishes. It is inflammable and on exposure air becomes resinous owing to absorption of oxygen. he oils from different varieties of pines differ in composi- on and properties and are divided into three varieties. rench turpentine consists chiefly of the terpene tere- enthene: American turpentine contains the terpene ustralene, and Russian turpentine contains the terpene lvestrine and a pinene similar to australene. The sinfectant, "Sanitas," is prepared by passing air into ussian turpentine in the presence of warm water.

Much turpentine is also produced by destructive stillation of resinous pine wood. Steam is injected to the retort to facilitate the extraction; acetic acid nd methyl alcohol are also produced as by-products.

Camphor ($C_{10}H_{16}O$) is a white translucent substance ith a very strong penetrating smell and pungent taste. is volatile even at ordinary temperature and burns with smoky luminous flame. It is only slightly soluble in ater but easily dissolves in the usual organic solvents – cohol, ether, chloroform, etc. It is used in the prepara- on of explosives and celluloid as well as in medicine, and an insecticide. Camphor is prepared by distillation of he trunk and branches of Japanese camphor laurel with ater and purified by sublimation. Chemically, camphor a ketone.

Artificial camphor is prepared by oxidation of borneol isoborneol, or from pinene by passing hydrochloric acid as into it.

Thymol ($C_{10}H_{13}OH$) is a phenol which occurs along ith the hydrocarbons cymene, $C_{10}H_{14}$, and thymene, $_0H_{16}$, in oil of thyme. The oil is washed with caustic da solution and the thymol precipitated from solution the addition of hydrochloric acid. Thymol is a

crystalline substance with the fragrant smell of thyme. Like many other phenols it possesses powerful antiseptic properties and is much used in medicine.

Menthol ($C_{10}H_{19}OH$) is an alcohol and the chief constituent of oil of peppermint to which it imparts its characteristic smell. It is extracted from oil of peppermint in solid form by cooling. Menthol is a crystalline substance employed as an antiseptic and anæsthetic.

Eucalyptus Oil is obtained by distillation of the leaves of the Australian eucalyptus tree, Eucalyptus globulus. It consists of a mixture of several terpenes and is used in perfumery and medicine.

Oil of Wintergreen ($C_6H_4(OH)COOCH_3$) is the methyl ester of salicylic acid. It is a fragrant liquid extracted from the leaves of a heath, Gaultheria procumbens, grown in U.S.A. and Canada. Artificial oil of wintergreen is prepared from salicylic acid by heating with methyl alcohol and sulphuric acid. Both natural and artificial forms are largely used for therapeutic and flavouring purposes.

Oil of Lavender is prepared by distillation of the flowers of lavender (Lavandula vera). When first prepared it has practically no smell which is only developed after exposure to air. It is used in perfumery and consists of a mixture of unsaturated olefinic terpenes, as do other perfume oils such as geranium oil, citronella oil, lemon grass oil and attar of roses.

Essences. Natural fruit essences are solutions in alcohol of the essential oils and esters of fruits which flavour any goods in which they are used. With the exception of a few notable cases, e.g., vanilla essence, it is impossible to extract the distinctive flavours from fruits in sufficient quantity and of sufficient strength for flavouring purposes. The majority of essences are artificial products prepared by mixing essential oils and esters with alcohol. The aroma and flavour of such artificial essences are seldom as delicate or as fragrant as the natural product they attempt to imitate. In certain cases an artificial essence contains only a single substance dissolved in alcohol but more usually varying proportions of several substances are used before a close approximation to the natural product is achieved. The usual method of manufacture is

mix together 70-75 parts by weight of rectified alcohol, 3-5 parts glycerine, 5-10 parts of essential oils and esters and the whole de up to 100 parts with distilled water.

The chief essential oils used in the manufacture of essences have eady been described. The chief esters used are ethyl formate OOC_2H_5, ethyl acetate $CH_3COOC_2H_5$, ethyl butyrate, C_3H_7 OC_2H_5, amyl acetate $CH_3COOC_5H_{11}$, amyl valerate $C_4H_9COOC_5$ $_1$, ethyl oenanthate, $C_8H_{17}COOC_2H_5$, methyl salicylate C_6H_4 $H)COOCH_3$, ethyl nitrite (sweet spirits of nitre), $C_2H_5NO_2$, yl benzoate, $C_6H_5COOC_2H_5$, amyl butyrate $C_3H_7COOC_5H_{11}$. addition such substances as chloroform, $CHCl_3$, acetaldehyde $_3CHO$, and tartaric, oxalic, succinic and benzoic acids are used to part a sharp sour flavour where necessary.

The essences which consist of practically a single ester in alcohol :

Pineapple essence	... ...	Ethyl butyrate in alcohol.
Jargonelle pear essence	...	Amyl acetate in alcohol.
Apple essence	... ...	Amyl valerate in alcohol.

Finally it should be noted that in certain cases better results are ained by using the actual source of the flavouring rather than essence or essential oil. Thus finely cut orange and lemon ls mixed in cakes give a superior flavour to that obtained with her the oils or essences.

ueurs. In the preparation of liqueurs the fruits or herbs are first bruised and then steeped in uted grain spirits or rectified alcohol. After sufficient eping the volatile constituents extracted by the ohol are separated by distillation and the distillate eetened by the addition of sugar. The product is n stored in wooden casks to mature and is finally ttled. It will thus be seen that they are similar to ences and contain essential oils dissolved in an alcoholic up. The chief liqueurs are Kirchwasser, Maraschino, nedictine, and Crême de Menthe.

Kirchwasser or Cherry Water is prepared in the Black rest and certain parts of Switzerland from a dark wild rry which is fermented along with the kernel.

Maraschino like Kirchwasser is also prepared from rries, but only the pulp is used. It is one of the eetest of liqueurs. Other ingredients such as cherry

leaves, raspberries and orris roots are added in certain varieties.

Benedictine is the most famous of liqueurs and derives its name from the fact that it was originally made by the monks of the Abbey of Fécamp in Normandy. The herbs used in the original Benedictine are unknown, and since the expropriation of the monasteries in France imitation Benedictines have been prepared from nutmeg, peppermint, hyssop and angelica with the addition of a large amount of sugar.

Crème de Menthe is prepared from peppermint, sage, orris root, cinnamon, and sugar. The natural green colour of the genuine article is imitated in cheap grades by the addition of dyes.

Other liqueurs which may be mentioned are Chartreuse, Angostura, Curaçao and Crême de Moyan.

Fruit Juices. In the preparation of fruit juices the fruit is first cleaned and then boiled for half an hour. The juice is then strained off and left to stand for a day when it is again boiled for half an hour. Any scum which rises to the surface is removed and sugar added at the rate of one pound to each gallon of juice. After the addition of the sugar the liquid is again brought to a boil and skimmed if necessary. The liquid is next poured into warm sterilised bottles and heated for about ten minutes in a pan of boiling water. The bottles are then sealed with sterilised covers. In the case of fruit syrups 50 per cent. of sugar is added to the sterilised fruit juice, which is then boiled and skimmed until no further scum rises to the surface.

Colouring Materials.

Not only are baked goods frequently made more palatable to the taste by the use of flavouring material but their appearance is also made more pleasing to the eye by the addition of colouring materials. The colours used are natural animal or vegetable products such as

chineal, turmeric, annatto, saffron and spinach juice, d artificial coal tar dyes such as are used in textile eing. Of the two types the artificial dyes on account their very wide range in colour are the more important. e shall confine ourselves at this point to the natural es. It will be well however, to mention that the blic Health (Preservatives, etc., in Food) Regulations ohibit the use of the following dyes in food materials account of their poisonous character :—

Metallic Colours : Compounds of antimony, arsenic, cadmium, chromium, copper, mercury, lead and zinc.

Vegetable Colours : Gamboge.

Coal Tar Colours : Picric acid, Victoria yellow (saffron substitute, di-nitro-cresol), Manchester yellow, (Naphthol yellow, Martius yellow), Imperial yellow (aurantia) and aurine (rosolic acid, yellow coralline).

Cochineal or Carmine is prepared from the female insect occina) which feeds upon a variety of cactus (Coccus cti), native to Mexico and Peru and cultivated in uatemala and the Canary Islands. The cochineal rived from the cultivated cactus is superior to that from e wild cactus of Mexico and Peru. The former is known mmercially as mestèque or grava fina, and the latter as lvestra.

The female insects are collected and destroyed by rowing them into hot water, and are then dried in the n or in stoves. This treatment gives the black cochineal-catilla. Alternatively, the insects may be placed in gs and dried in stoves without previously destroying hot water. By this method the silvery-white cochineal anco is obtained. The essential colouring principle of chineal is carminic acid. The usual forms in which chineal is used are cochineal liquid, carmine and carmine uid, and the usual mordant used in such preparations alumina.

Turmeric or Indian Saffron is obtained from the underound stem or rhizome of the Curcuma longa, a plant of e ginger family which is native to Southern Asia and

cultivated in India, East Indies and China. The powdered rhizome is used to colour curries, mustard-pickles and egg powder. It is seldom used in cakes in spite of its egg-like colour because of the presence in it of a volatile oil with an acrid taste.

Annatto is prepared from the fermented seeds and pulp surrounding them of the plant Bixa Orellana, which is native to South America and cultivated in the West Indies and Ceylon. The dye is sold as an orange paste or as small seeds with an orange covering. The colouring material, bixin, is practically insoluble in water but easily soluble in alcohol. Its chief use is in the colouring of butter, margarine, cheese and milk.

Saffron is obtained from the dried stigmas of the flower of the plant Crocus sativus, which is grown in Spain, France, Austria and Italy. It requires 60,000 flowers to produce a pound of dried saffron. When steeped in hot water and alcohol it gives an orange-yellow colour which is much used in cakes, pastries, cordials and liqueurs. Its colour changes from yellow to brown on gently heating (300-400 F.) and it should be used fresh for it decomposes quickly even at ordinary temperatures. Saffron is marketed as "cake saffron"—in cake form—and as "hay saffron," in which the stigmas are kept separate.

Spinach is a vegetable native to Northern Asia and cultivated in this country. The colour is obtained from the leaves. Apple-green is obtained by tinting spinach green with a yellow dye.

Finally, a colouring material used in foodstuffs, whether a natural or an artificial dye, should be non-poisonous, unaffected by acids which might be present in the food or formed in it by fermentation, fast to light, unaffected by alkalies, e.g., bicarbonate of soda, and have no unpleasant smell or taste. No colouring material of whatever type has any food value. The chief artificial dyes used in food materials are magenta, azo and eosin dyes (red), azo dyes (yellow), malachite (green), methyl violet, methylene blue, ultramarine and indigo.

EXPERIMENTAL WORK ON ARTIFICIAL COLOURING MATTERS IN FOODS.

The artificial colouring matters may be grouped into three main sses, according to their origin :—

(i) Naturally occurring organic colours of vegetable or animal origin.

(ii) Synthetically prepared organic colours or dyes.

(iii) Mineral or inorganic colours, pigments and lakes.

The majority of colouring matters belonging to the first class harmless and most of the organic dyes used are not harmful en present in small amounts. Many mineral colours, on the er hand are definitely poisonous and their use in foods is pro-ited.

t is generally fairly easy to test whether any artificial colouring tter is present in food and even to identify the type of colour ed. The identification of the actual dye or mixture of dyes used however, a matter of much greater difficulty.

getable Colours.

The commonest of these are turmeric, saffron and annatto and se being yellow, might be used in "egg powders."

The other important natural colour is cochineal.

thetic organic colours Coal tar dyes.

A great variety of coal tar dyes can be used in foods and while s possible to identify them as such and the class to which they ong, it is often impossible, and for our purpose unnecessary, to ntify the particular dye or combination of dyes present. These the commonest colouring materials in foods.

mination of the Colouring Matter in "Egg Powder" or "Sponge Mixture."

Egg powders are usually coloured baking powders and sponge tures usually contain flour, raising agents, and flavouring and uring matters.

) Shake up 5-10 gms. of the powder with about 20 ccs. of luke-m water. Allow to stand until effervescence has ceased and luble material has settled out. Observe whether the material is ured or not.

the extract is coloured, filter off the insoluble material and dify the filtrate with a few drops of hydrochloric acid. If the tion changes from yellow to orange or red on the addition of , an "acid" coal tar dye is present. If the colour becomes h paler on the addition of acid, a coal tar dye known as naphthol w may be present.

Now introduce into the acidified solution a strip of white woollen material, e.g., "nun's veiling," which has previously been freed from grease by boiling for a few minutes in a dilute sodium carbonate solution and then thoroughly rinsed in hot water. Boil for 10 minutes. Remove the wool and boil it for a few minutes, first in water containing a little hydrochloric acid and then in water only. Note whether the colour is taken up by the wool. With very few exceptions the coal tar dyes used in foods are taken up by, and dye wool directly without the addition of a mordant.

(ii) Shake up another portion of the powder with alcohol and allow to stand until the insoluble matter has settled. As in the water-extract note whether a coloured extract is obtained and also whether the alcohol appears to extract more colour than the water. If a coloured extract is obtained, filter off the insoluble matter and acidify the filtrate with dilute hydrochloric acid. If a "basic" coal tar dye is present the colour will be soluble in alcohol but not in water and on the addition of acid to the alcoholic solution the colour will change to red or pink.

In cases where a distinctly coloured alcoholic extract is obtained and little or no colour extracted by water, or if dyeing from the aqueous extract is unsatisfactory, the acidified alcoholic extract should be used to dye a second strip of prepared woollen material. If the alcoholic extract is distinctly yellow but shows no change in colour on the addition of hydrochloric acid a portion of the solution should be tested for turmeric in the following manner.

Transfer a portion of the acidified alcoholic extract to an evaporating basin, add a few drops of an aqueous solution of borax and evaporate to dryness on a water-bath. A bright red or pink residue which turns bluish-green on the addition of alkali indicates the presence of turmeric.

If the colour is not extracted either by water, dilute acid or alcohol, then a mineral pigment or lake may be present although as previously pointed out this is now unlikely.

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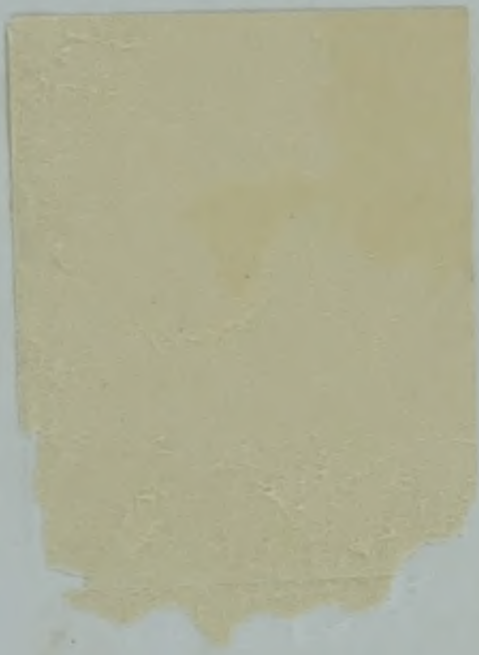
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